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A Comparison Of Adults' And Children's Understanding Of And Memory For Potential Inference Sentences

Rosalind Stacey

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A COMPARISON OF ADULTS' AND CHILDREN'S UNDERSTANDING OF AND MEMORY FOR POTENTIAL INFERENCE SENTENCES

by

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of the requirements for the degree of
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ABSTRACT

Research on adults' understanding of potential inference sentences of the spatial type has employed material such as Sentence (1).

(1) Three turtles rested on a floating log and a fish swam beneath them.

An adult not only understands the direct content of Sentence (1) (that is, that the fish swam beneath the turtles) but can also derive the inference (that is, that the fish swam beneath the log). Adults have been presented with sentences such as Sentence (1) and asked either the direct question (2) or the inference question (3).

(2) Did the fish swim beneath the turtles?

(3) Did the fish swim beneath the log?

Previous research has demonstrated that when the question is asked immediately following the presentation of the potential inference sentence, inference questions take significantly longer to answer than direct questions do. This indicates that at the immediate point of comprehension of the sentence, the adult has not drawn the inference. However, when 7.5 seconds are allowed to elapse between the presentation of the sentence and the question about it, there is no significant difference between the latencies to the two types of questions. Therefore, during the interval between the sentence and the question, the subject produces the inference and the subject's memory for the sentence is in the form of a construct which includes both the direct content and the inference.

The present study explored two questions. First, are six- and ten-year-old children capable of drawing spatial inferences and secondly, will the children's memory for the potential inference sentence assume the form of a construct.

Adults, six-year-olds, and ten-year-olds were compared on their processing of potential inference sentences by using the technique of immediate and delayed presentation of direct and inference questions. It was established that the adults drew inferences correctly approximately 90% of the time. The ten-year-olds drew inferences 70% to 80% of the time and the six-year-olds performed at the chance level.

It was confirmed that, with adult subjects, inference questions take significantly longer to answer than direct questions when no delay is imposed between the potential inference sentence and the question. However, after a delay of 17 seconds, there was no significant difference between the response latencies to the two types of questions. Therefore, after the delay the adults' memory for the sentence was in the form of a construct which included both the direct content and the inference. The ten-year-old subjects demonstrated a good memory for the content of the potential inference sentence after a delay, but, nevertheless, the latency of their responses to inference questions was still significantly longer than the latency of their responses to direct questions. This indicates that their memory for the sentence did not include the inference. The six-year-olds were not proficient in drawing inferences and during the delay interval tended to forget much of the sentential material.

It was concluded that, despite the ten-year-olds' relative proficiency at drawing inferences, they did not do so spontaneously during the delay interval between the presentation of the sentence and the question. This indicates that there is a developmental lag between the age at which the ability to solve a problem is acquired and the age at which this ability is applied spontaneously.

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CHAPTER I

OUTLINE OF THE PROBLEM

In the past decade attention has been focused on the form which meaningful verbal material assumes in memory. Materials which were initially developed to explore this problem with adults have recently been used in research with children. The first part of this chapter is devoted to a brief review of the adult research on semantic integration and memory for material from which inferences may be drawn. The second part of the chapter is concerned with the research on children and the similarities and differences between children's and adults' performances. At the end of the chapter, there will be a discussion of one particular problem, namely, the ability of children to draw spatial inferences and to recall inferential material.

Research with Adults

In 1971, Bransford and Franks demonstrated experimentally that subjects will spontaneously integrate the information contained in sentences which are semantically related, but are not consecutively presented. This phenomenon is known as semantic integration. The preparation of the verbal material used in the experiment required some ingenuity. Initially, four complex English sentences such as Sentence (1) were created.

(1) The ants in the kitchen ate the sweet jelly which was on the table.

These complex sentences (called FOURS) were then broken down into their constituent simple sentences (called ONES), each of which contained part of the idea expressed by the complex sentence. Sentences (2), (3), (4), and (5) are the ONES which were derived from Sentence (1).

(2) The ants were in the kitchen.

(3) The jelly was on the table.

(4) The jelly was sweet.

(5) The ants ate the jelly.

By combining the ONES in pairs, sentences called TWOS were created. Sentence (6), which is a combination of Sentences (2) and (5) is an example of a TWO.

(6) The ants in the kitchen ate the jelly.

Similarly, by combining the information contained in three ONES, THREES were created.

For each of the original FOURS, the set of all possible ONES, TWOS, and THREES was constructed. Then the acquisition list was created by drawing from each set two ONES, two TWOS, and two THREES. Thus, although the subjects were never exposed to the original FOUR, they heard six sentences which in combination contained the entire idea expressed by the FOUR. The six sentences which came from the same set were not presented consecutively. Instead, the sentences in the acquisition list were ordered so that, in each successive sequence of four sentences, there was one sentence from each set.

After the acquisition list had been presented, there was a 5-minute break. The subjects were then given the recognition task. The recognition list was composed of FOURS (which the subjects had never heard) and THREES, TWOS, and ONES (some of which were acquisition sentences and some of which were new). The subjects were required to indicate which sentences they had heard before and which ones they had not. In addition, the subjects were asked to rate how confident they were about their recognition judgments on a 5-point confidence scale, from "very high" to "very low".

In analyzing the data, the recognition response and confidence rating were combined to give a single score. A "yes" response (which indicated recognition of a sentence) received a "plus" and a "no" response received a "minus". A "very high" confidence rating received a 5 and a "very low" confidence rating received a 1. Thus, a "yes" response made with "very high" confidence became a score of +5 and a "no" response made with "very low" confidence became a score of -1. A score was obtained for each of the recognition list sentences by averaging over all the subjects' scores for that sentence. The sentences were then placed in their appropriate categories (ONE, TWO, THREE, or FOUR) and a mean score was obtained for each sentence category. The rank order of these scores was FOURS > THREES > TWOS > ONES, despite the fact that the subjects had not heard the FOURS during acquisition. In addition, subjects did not discriminate reliably between acquisition sentences and new sentences.

Bransford and Franks concluded that the subjects' attempts to recognize acquisition sentences were a function of the complete

idea, acquired through the integration of information expressed across a number of different sentences. Thus, the subjects were most confident of recognizing these sentences which expressed the complete idea, that is, the FOURS. The subjects became less confident in their recognition of a sentence as a function of the extent to which the sentence failed to encompass the entire idea. Hence, the THREES received lower scores than the FOURS and the ONES received the lowest scores of all.

In a subsequent study, Bransford and Franks (1972) again demonstrated semantic integration. In this experiment, the acquisition material consisted of paragraphs which contained truncated passive sentences, that is, passive sentences in which the actor is not mentioned. Bransford and Franks found that when the deleted actor was not mentioned elsewhere in the passage, subjects tended to recall the truncated passive sentence verbatim. However, when the deleted actor was mentioned in another sentence in the paragraph, there was a significant increase in the probability that the subjects would remember the truncated passive as a full passive sentence (that is, as a passive sentence in which the actor was expressed) or as an active sentence. The subjects appeared to be storing the truncated passive sentence and the subsequently-mentioned actor as a wholistic entity rather than as separate pieces of information.

In the studies reported by Bransford and Franks (1971, 1972) the subjects integrated acquisition sentences and later recalled and "recognized" an idea which was the product of this integration. These experimental results can be accounted for by the interpretive

theory proposed by Sachs (1967). The interpretive theory takes as its starting point the observation that when a sentence is understood the meaning of what was heard is remembered while the exact wording is forgotten. Sachs presented a model of comprehension derived from linguistic theory to explain this phenomenon. Sachs' linguistic model of the analysis of a sentence is as follows:

Sounds - - physical stimuli
↕
Surface Structure - the sentence perceived as words and phrases
↕
Deep Structure - representation of the sentence which expresses the grammatical relationships independent of the ordering in the surface structure
↕
Meaning

According to this model, the deep structure is derived from the surface structure by syntactic processing and a semantic interpretation is made from the deep structure. Characteristics of the surface structure that are not uniquely related to the meaning may be forgotten after comprehension. Thus, a sentence may not be recalled in its exact wording, but rather in another wording which expresses the same deep structure or meaning. The interpretive theory would account for the phenomenon of semantic integration as demonstrated by Bransford and Franks (1971, 1972) in terms of the concatenation of sentential deep structures and the forgetting of syntactic detail.

However, Bransford, Barclay, and Franks (1972) produced evidence which challenged the interpretive theory of sentence memory. In this study, subjects inferred information from acquisition sentences and on a subsequent recognition task they were unable to distinguish

between the original acquisition sentence and its inference. Bransford et al. argued that these results lent support to their constructive theory of memory for sentences, as opposed to Sachs' interpretive theory. Bransford et al. suggested that a listener can use information in a sentence to construct semantic descriptions which contain more information than is represented in the linguistic input. An example from Bransford et al. may help to clarify the difference between the interpretive and constructive positions. Consider these two sentences:

(1) Three turtles rested beside a floating log and a fish swam beneath them.

(2) Three turtles rested on a floating log and a fish swam beneath them.

The situations suggested by the two sentences differ. Sentence (1) contains information about a fish swimming beneath turtles. Sentence (2) includes this information and some additional information, as well. Since the turtles were resting on the log, and the fish swam beneath them, the fish also swam beneath the log. The information that the fish swam beneath the log was provided by one's knowledge of the world. Subjects hearing either Sentence (1) or Sentence (2) can be presented with a recognition sentence in which the final pronoun has been changed; that is,

(3) Three turtles rested beside/on a floating log and a fish swam beneath it.

The interpretive and constructive theories make different predictions about whether or not the subject will think that he heard

Sentence (3) before (see Table 1). In the interpretive theory, the subject stores only the linguistic information in the original sentence. Therefore, if a subject hears either Sentence (1) or Sentence (2), he would detect the pronoun change in Sentence (3) with equal facility.

According to the constructive theory, a subject creates a semantic description of the situation. A subject who heard Sentence (1) would reject Sentence (3) because it does not agree either with the actual sentence he heard or with the constructed description. Sentence (1) is called a non-inference sentence because when the subject hears it he does not infer the information contained in Sentence (3). However, if a subject heard Sentence (2) and was later presented with Sentence (3), he might judge the two to be the same, since Sentence (3) agrees with the constructed semantic description. Sentence (2) is called a potential inference sentence because when a subject hears it he may infer the information contained in Sentence (3).

Bransford et al.'s first experiment contrasted the interpretive and constructive approaches. In the acquisition portion of the experiment, 18 subjects heard 21 sentences. There were seven potential inference sentences, seven different non-inference sentences, and seven filler sentences. Following a 3-minute break, the subjects heard 35 recognition sentences. Fourteen of the recognition sentences were the potential inference and non-inference sentences heard during acquisition (old potential inference and old non-inference, respectively). In addition, there were 14 new potential inference

TABLE 1

Predictions Made by the Interpretive and Constructive Theories about Subjects' Recognition Performance

---

Non-Inference Sentences

1. Old Sentence

   Three turtles rested beside a floating log and a fish swam beneath them.

3. New Sentence

   Three turtles rested beside a floating log and a fish swam beneath it.

Interpretive theory: "different"

Constructive theory: "different"

Potential Inference Sentences

2. Old Sentence

   Three turtles rested on a floating log and a fish swam beneath them.

3. New Sentence

   Three turtles rested on a floating log and a fish swam beneath it.

Interpretive theory: "different"

Constructive theory: "same"

---

and new non-inference sentences, which were created by changing the final pronoun in the old potential inference and old non-inference sentences (see Table 1). There were seven filler sentences. Of these, four were in their original form (old filler) and three were changed from their original form (new filler).

The subjects were told that after they had heard each recognition sentence, they were to indicate whether or not they had heard that exact sentence during acquisition. In addition, they were to rate their confidence in each response on a 5-point scale ranging from "very high" to "very low". As in Bransford and Franks (1971), the recognition response and confidence rating were combined to give a single score, the value of which could range from +5 to -5. The mean recognition scores were calculated for each of the six categories of sentences: (1) old potential inference, (2) new potential inference, (3) old non-inference, (4) new non-inference, (5) old filler, and (6) new filler. A 2-factor analysis of variance was performed on these scores. The two factors were recognition status (old versus new) and sentence type (potential inference, non-inference, and filler). The results supported Bransford et al.'s predictions. There was a significant interaction between recognition status and sentence type ($p < .001$). For both non-inference and filler sentences, the old sentences were rated significantly higher than the new sentences ($p < .001$). However, the difference between old and new potential inference sentences was not significant, that is, subjects could not distinguish between old and new potential inference sentences.

As Bransford et al. pointed out, the fact that the subjects' inability to differentiate old from new sentences was confined to potential inference sentences offers support for their constructive theory, but further evidence was needed. It was possible that potential inference sentences were just more poorly remembered than non-inference sentences, and hence the subjects had greater difficulty in distinguishing between old and new potential inference sentences than they did in distinguishing between old and new non-inference sentences.

In order to test this alternative hypothesis, Bransford et al. conducted a second experiment in which the subjects were required to recall the acquisition sentences rather than to recognize them. As in the first experiment, the acquisition list consisted of seven potential inference sentences, seven non-inference sentences, and seven filler sentences. On the recall task, subjects were given the noun phrase of the sentence (for example, "three turtles") and were required to write down the rest of the sentence. The data from this experiment were analyzed in two ways. In the first analysis, the accuracy of the recall of the potential inference and non-inference sentences up to, but not including the final pronoun, was considered. Bransford et al. reported that 34% of all the sentences were paraphrased accurately. Of the sentences that were paraphrased accurately, 54% were potential inference sentences and 46% were non-inference sentences. The difference between these two scores was not significant. Thus, it appears that potential inference sentences are not generally recalled more poorly than non-inference sentences.

In the second analysis, the experimenters examined recall of the final pronoun, given correct recall of the first part of the sentence. For non-inference sentences, 76% of the final pronouns were recalled correctly; for potential inference sentences, 57% were recalled correctly. This difference was significant ($p < .025$). Thus, despite the fact that potential inference sentences were generally recalled as well as non-inference sentences, the final pronoun in the potential inference sentences were more poorly recalled. This offers further support for the constructive theory.

In a subsequent experiment, Bransford et al. produced more evidence to support their constructive theory. In this experiment, the acquisition material consisted of six descriptive paragraphs. Each paragraph contained two premises and one filler sentence. An example is as follows:

(1) The box is to the right of the tree. (premise)

(2) The chair is on top of the box. (premise)

(3) The tree is green and extremely tall. (filler)

There were two sets of recognition material, "original recognition sentences" and "propositionally similar recognition sentences". The four original recognition sentences always included: a true premise identical to one of the acquisition sentences (4); a false premise in which one of the relational terms of the original premise was changed (5); a true inference derived from the relationships expressed in the acquisition sentences (6); a false inference which could not be derived from the acquisition sentences (7).

(4) The box is to the right of the tree. (true premise)

(5) The box is to the left of the tree. (false premise)

(6) The chair is to the right of the tree. (true inference)

(7) The chair is to the left of the tree. (false inference)

In the four propositionally similar recognition items, the information contained in the original recognition sentences was conveyed by using the opposite relational terms. The propositionally similar sentences which correspond to Sentences (4) to (7) are:

(8) The tree is to the left of the box. (new true premise)

(9) The tree is to the right of the box. (new false premise)

(10) The tree is to the left of the chair. (new true inference)

(11) The tree is to the right of the chair. (new false inference)

At the time of recognition, half the subjects were presented with the original recognition sentences and half received the propositionally similar sentences. The subjects were asked to indicate which of the four recognition sentences they had actually heard during acquisition. With the subjects who heard the original recognition list, 42% of the responses were correct identifications of the true premise. The true inference was "recognized" 29% of the time, while the false premise and false inference received 16% and 13% of the "recognition" responses respectively. Thus, when the subject forgot the actual wording of the sentence, he was much more likely to "recognize" the true inference than either of the false sentences. This result, by itself, would not support the constructive theory over the interpretive theory, since "recognition" of the true inference could be explained by the forgetting of syntactic detail accompanied by the chaining of the deep structures of the two premise sentences.

However, the interpretive theory could not explain the results obtained from the subjects who received the propositionally similar recognition sentences. For these subjects, none of the recognition sentences was identical to the true premise. Nevertheless, a total of 70% of the "recognition" responses were given to the new true premise and new true inference and only 30% of the responses were made to the new false premise and the new false inference. The subjects had spontaneously converted sentences such as "The box is to the right of the tree" to the logical equivalent "The tree is to the left of the box" and therefore, they "recognized" those sentences which preserved the meaning of the acquisition material and rejected those sentences which did not.

Bransford et al. concluded that the experiments indicated that sentence recognition is not merely a function of the information specified by the linguistic input strings, but rather it is a function of the complete semantic description the subject constructs. The constructive approach does not deny the psychological reality at some level of linguistic representation in memory. One can recall the linguistic representation in addition to the semantic descriptions suggested by the linguistic inputs. However, the constructive approach does deny that a specification of the linguistic representation is a complete characterization of the information available to the listener. The linguistic inputs serve as cues, and what is comprehended and remembered depends upon an individual's general knowledge of his environment.

The next study to be reviewed is Jenkins' (1971) research on memory for linguistic information. The purpose of the study was to determine at what point in time the drawing of inferences occurs. On the one hand, it is possible that the drawing of an inference is a normal part of the immediate comprehension of a sentence. If the drawing of an inference is part of the immediate comprehension of a sentence, then Bransford et al.'s (1972) results could be subject to a different interpretation from the one that Bransford et al. made. Perhaps, at the immediate point of comprehension of a sentence, the listener possesses both the syntactic and lexical details and the "enriched" constructive meaning. With the passage of time, the subject would forget the syntactic and lexical details and retain only the enriched construct. Thus, Bransford et al.'s results would be attributed to forgetting during the delay rather than to the formation of a construct. On the other hand, perhaps inferences are drawn at some point after the immediate comprehension of the sentence and are a part of the sentence as it is stored in memory.

In order to study this problem, one needs to compare the latency of subjects' responses to questions which require that inferences be drawn to the latency of responses where no inferences are required. At this point, a description of the verbal material Jenkins used would be appropriate.

The first point is terminology. If one examines sentences of the type that Bransford et al. and Jenkins used, it appears that in each sentence there are one actor and two recipients of the action. For example:

(1) Two robins (N_1) crouched on their nest (N_2) and a hawk (actor) flew over them (N_1).

The actor is the hawk. The recipients of the action are the robins and, by implication, the nest. The first recipient to appear in the sentence has been called (by Jenkins) the N_1. In this example, N_1 is robins. The second recipient in the sentence is N_2, in this case, the nest. Sentence (1) is called an N_1 sentence because it states directly that the recipient of the action was the N_1 (that is, "a hawk flew over them," where them = robins). For the sake of convenience, one could think of an N_1 sentence as a sentence where the final pronoun refers to N_1. One could also think of an N_1 sentence as a sentence where N_1 gets mentioned twice. Similarly, Sentence (2) is an N_2 sentence.

(2) Two robins (N_1) crouched on their nest (N_2) and a hawk flew over it (N_2).

It is also possible to write N_1 and N_2 questions. This is an N_1 question:

(3) Did the hawk fly over the robins (N_1)?

In (3) the noun that is being queried (robins) is the N_1 of Sentences (1) and (2). The corresponding N_2 question would be:

(4) Did the hawk fly over the nest (N_2)?

In (4) the question is about the N_2 of Sentences (1) and (2). Since there are two sentences (N_1 and N_2) and two questions (N_1 and N_2), there are four possible sentence-question combinations. The four combinations are:

Direct Items

(N_1 Sentence - N_1 Question) (N_1N_1)

N_1 Sentence: Two robins crouched on their nest and a hawk flew over them.

N_1 Question: Did the hawk fly over the robins?

(N_2 Sentence - N_2 Question) (N_2N_2)

N_2 Sentence: Two robins crouched on their nest and a hawk flew over it.

N_2 Question: Did the hawk fly over the nest?

Inference Items

(N_1 Sentence - N_2 Question) (N_1N_2)

N_1 Sentence: Two robins crouched on their nest and a hawk flew over them.

N_2 Question: Did the hawk fly over the nest?

(N_2 Sentence - N_1 Question) (N_2N_1)

N_2 Sentence: Two robins crouched on their nest and a hawk flew over it.

N_1 Question: Did the hawk fly over the robins?

Combining an N_1 sentence and an N_1 question or combining an N_2 sentence and an N_2 question creates a direct item; that is, the information needed to answer the question is immediately available to the subject and the subject does not need to draw an inference from the sentence in order to answer the question. If one combines an N_1 sentence with an N_2 question, or an N_2 sentence with an N_1 question, the item is in the inference form; that is, information necessary to

answer the question must be inferred from the sentence and other sources.

In order to determine whether or not the drawing of inferences takes place as soon as the sentence is understood, the following general method can be used. A subject can be presented with a number of items, half of which are inference items, and half of which are direct. After each sentence is read, the subject is asked the question and the latency of response is recorded. If the drawing of inferences is an immediate part of sentence comprehension, then there should be no significant difference between the latencies to the two types of questions. On the other hand, if the drawing of inferences requires further processing of sentences, then it should take longer to answer items in the inference form.

If it does take significantly longer to answer inference items than direct, the next logical question would be: At what point in time does the representation of the sentence come to include the inference? From the work of Bransford et al., we know that if at least three minutes are allowed to lapse between the presentation of the sentence and the probe, the subjects respond on the basis of inferences, but perhaps less time is required. In order to explore this question, one can interpolate varying amounts of material between the potential inference sentence and the question. At some point, the memory representation of the sentence would be such that the direct and inference answers would be equally available to the subject and the difference in latencies between direct and inference items would disappear.

Jenkins used three levels of interpolated material: no interpolated material, one 15-word sentence (approximately 7.5 seconds), and two 15-word sentences (approximately 15 seconds). The interpolated material was not related to the potential inference sentence. Since response latencies tend to vary from person to person, a within-subject design was used. Thus, each subject heard six inference items and six direct items. Of the six inference items, two had no interpolated material (0 IM), two had 15 words of interpolated material (15 IM), and two had 30 words of interpolated material (30 IM). Similarly, there were two direct items at 0 IM, two at 15 IM, and two at 30 IM.

Table 2 shows the mean latency of correct responses as a function of item type and amount of interpolated material. A 2-factor repeated measures analysis of variance was performed on these latency scores. Item type had a significant effect, with inference items having significantly longer latencies than direct items ($p < .0005$). There was no significant main effect of interpolated material. The interaction between item type and interpolated material was significant ($p < .02$).

The significance of the difference between inference and direct items at each level of interpolated material was determined by post hoc tests. With no interpolated material, inference items had significantly longer latencies than direct ($p < .01$). There was no significant difference between inference and direct items at 15 words of interpolated material. However, at 30 words of interpolated material, there was a significant difference between inference and direct items, with inference items again having longer latencies ($p < .01$).

TABLE 2

Mean Latency in Seconds of Correct Responses as a Function of Item Type and Amount of Interpolated Material

(from Jenkins, 1971)

Item Type	Amount of Interpolated Material		
	0 Words	15 Words	30 Words
Direct	2.53	2.73	2.48
Inference	2.89	2.71	2.71

The significant difference between the mean response times for inference and direct items at zero words of interpolated material indicates that at the point of immediate comprehension of a sentence, the potential inference is not included in the mental representation of the sentence. The fact that the difference between inference and direct items disappears after 15 words of interpolated material (approximately 7.5 seconds) would appear to indicate that at that point in time, a construct has been formed such that the inference is part of the memory representation of the sentence. However, the re-appearance of a significant difference after 30 words of interpolated material (approximately 15 seconds) poses a problem in interpretation. It does not seem probable that a subject, who has the inference after 15 words of interpolated material, loses it, only to regain it three minutes later (as Bransford et al., 1972, report). Jenkins suggested that subsequent studies might help to clarify the situation.

Non-spatial inferences. Jenkins (1971) and Bransford, Barclay, and Franks (1972) studied the recall of spatial inferences, but other types of inferences are possible. Johnson, Bransford, and Solomon (1973) used an experimental method similar to Bransford et al.'s but with different types of inferences. One type of acquisition sentence, like Sentence (1), contained the implication that an instrument was used in carrying out the action described in the sentence.

(1) He was pounding the nail when his father came out to watch him and help him do the work.

Another type of sentence implied the consequences of an action, for example, Sentence (2).

(2) The boy hit the baseball and watched as it flew into the picture window in the house.

There were two groups of subjects, experimental and control. During the acquisition phase, the experimental subjects heard sentences such as (1) and (2) which contained these tacit implications of an instrument or a consequence. The control subjects heard acquisition sentences which were similar in wording, but did not contain these implications. Sentence (3) is the control sentence which corresponds to experimental Sentence (1).

(3) He was looking for the nail when his father came out to watch him and help him do the work.

During the recognition phase, the control and experimental subjects heard the acquisition sentences which had been presented to their respective groups. In addition, both control and experimental subjects received new sentences in which the instrument or consequences which had only been implied in the experimental acquisition sentences were now stated explicitly. Sentence (4) is the new sentence derived from Sentence (1).

(4) He was using the hammer when his father came out to watch him and help him do the work.

The control subjects were able to discriminate reliably between their acquisition sentences and new sentences, but the experimental subjects did not. From these results, Johnson et al. concluded that at the time of recognition, the experimental subjects were working from a

construct which included the instruments and consequences which had been inferred from the acquisition sentences.

Additional evidence for the formation and recall of constructs from inferential material has been produced by using acquisition material which contained transitive implications (Barclay, 1973; Barclay & Reid, 1974a) and syllogisms (Tzeng, 1975; Graesser & Mandler, 1975). Therefore, it appears that with adult subjects, at least, the phenomenon reported by Bransford et al. (1972) is not restricted to spatial inferences.

Research with Children

Semantic integration. Research with children in the five- to ten-year-old age group indicates that with certain types of verbal material, at least, children are capable of semantic integration. Barclay and Reid (1974b) studied the recall of truncated passive sentences in children from five years, eight months to ten years, nine months of age. Barclay and Reid's results were essentially the same as those obtained by Bransford and Franks (1972) with adults. The children tended to recall the truncated passives verbatim when the actor which had been deleted from the truncated passive sentence was not mentioned elsewhere in the story. However, when the deleted actor was introduced later in the story, there was a significant increase in the tendency to recall truncated passives as active sentences or full passives. Barclay and Reid reported that there was no significant increase in the amount of semantic integration between the ages of five and ten. However, these authors cautioned

that developmental trends might be uncovered if different verbal materials were employed.

Paris and Mahoney (1974) reported a study using eight-year-old and ten-year-old children which was modelled on Bransford, Barclay, and Franks' (1972) experiment on adults' memory for descriptive paragraphs. Like Bransford et al., Paris and Mahoney employed both "original recognition sentences" and "propositionally similar recognition sentences". With the propositionally similar recognition sentences, the children gave the same percentage of recognition responses to true premises and true inferences, while the percentage of recognition responses to false premises and false inferences was significantly lower. These results are similar to those obtained by Bransford et al. with adults and would seem to indicate that the children were capable of integrating the semantic relationships expressed in the acquisition sentences and of recalling the product of this integration during the recognition task.

However, the results for the propositionally similar recognition items were somewhat different. The children performed at the chance level on these items; that is, they "recognized" each of the four types of sentences (new true premise, new true inference, new false premise and new false inference) equally often. This is in contrast to the results obtained from using propositionally similar items with adults, since the adult subjects tended to "recognize" new true premises and new true inferences while rejecting the new false premises and new false inferences. The children's responses on the propositionally similar recognition sentences indicate that children

do not spontaneously convert statements such as "The box is to the right of the tree" to the logical equivalent "The tree is to the left of the box.".

The children's memory representation of the information contained in the acquisition sentences is more closely tied to the original lexical form of these sentences than is the adults'. This finding that adult subjects tend to elaborate upon acquisition sentences more than children do parallels the results of Rohwer's research with adults and children in paired-associate learning (Jensen & Rohwer, 1965; Rohwer & Bean, 1973; Suzuki & Rohwer, 1969). (Rohwer's concept of elaboration will be discussed in Chapter III.)

Paris, Mahoney, and Buckhalt (1974) replicated Paris and Mahoney's study using new acquisition sentences and "original recognition sentences" only. The subjects in this experiment were seven- and eleven-year-old educable mentally retarded children. Paris et al. demonstrated that when imagery instructions were given prior to the acquisition phase of the experiment, there was a significant increase in "recognition" of true inference sentences.

Children's ability to draw inferences. To a great extent, the research on children's ability to draw inferences (Bradbury & Nelson, 1973; Murray & Youniss, 1968; Riley & Trabasso, 1974; Sharples, Sutton-Smith, Exner, & Rosenberg, 1968; Youniss & Murray, 1970) has focused on classical transitivity problems of the type: A > B, B > C, A?C. For example, transitivity problems have been presented to children using pairs of coloured sticks or lines of differing lengths. The child is shown the relationship between A and B,

then between B and C, and is asked about the relationship of A and C. It has been reported that between the ages of six and ten years there is a dramatic increase in children's ability to solve transitivity problems. This improvement in performance was first noted by Piaget (1964a) who described children in the two- to seven-year-old age range as being in the preoperational period while children in the seven- to eleven-year-old age range are in the period of concrete operations. Smedslund (1963) reported that only 30% of children aged 7-0 to 7-11 succeeded on the transitivity task, while 85% of children 9-0 to 10-0 did so. Similarly, Coon and Odom (1968) found that 40.4% of children aged 7-8 showed transitivity, while 81.5% of children aged 11-5 did so. Glick and Wapner (1968) employed transitivity items in which the premises were presented verbally. They reported that 54% of the eight-year-olds' responses and 70% of the ten-year-olds' responses were correct.

Experiments in which children are presented with classical transitivity problems provide us with information about the development of children's ability to draw inferences when the task explicitly requires them to do so. However, these experiments do not tell us at what age children spontaneously integrate information in order to arrive at an inferential conclusion. Recently, Paris and Lindauer (1976) conducted a series of experiments which were contemporaneous with the research to be described in the following chapter. These experiments were motivated by Johnson, Bransford, and Solomon's (1973) research on the tendency of adults to infer appropriate instruments when these instruments are not explicitly stated. The subjects in the first experiment were six, nine, and eleven years of age. The

acquisition material consisted of eight sentences, such as (1) and (2):

(1) The truck driver stirred the coffee in his cup (with a spoon).

(2) The workman dug a hole in the ground (with a shovel).

The experiment had a within-subject design. Each subject heard four sentences in which the instrument was mentioned explicitly and four sentences in which the instrument was omitted. In the recall portion of the experiment, the child heard the four explicit and the four implicit instruments which were to be used as cues in the recall of the sentences. The results indicated a definite developmental trend. With the eleven-year-old subjects, there was no significant difference between the number of implicitly-cued and explicitly-cued sentences recalled. However, the six- and nine-year-olds recalled significantly more explicitly-cued than implicity-cued sentences. It appeared, therefore, that the eleven-year-olds were spontaneously inferring the implied instrument and incorporating this instrument into their memory representation of the sentences so that the implicit instrument became an effective cue for the recall of the sentence. However, the younger subjects did not have the implicit instrument as part of their memory of the sentence, and hence, it was an ineffective cue.

In a second study, Paris and Lindauer established that young children are actually capable of inferring the correct instrument from a sentence if they are directed to do so. Five-year-old children were presented with the eight sentences used in the first experiment, with the instrument missing from each sentence. After each sentence had been read, the child was instructed to select the correct

instrument from among four pictures representing common instruments. The five-year-olds made the correct instrument choice on 97.7% of the trials.

In a subsequent experiment with seven-year-olds, the acquisition procedure was modified so that after the child had heard each sentence, he was required to act it out using an instrument which he chose from a selection of toys. As was the case in the first experiment, half the sentences stated the instrument explicitly and half did not. In the subsequent recall portion of the experiment, the seven-year-olds demonstrated a high level of recall for the acquisition sentences and they recalled explicitly-cued and implicitly-cued sentences with equal facility.

It appears that the younger subjects were capable of inferring instruments, but did not do so spontaneously. However, when inferring the instrument became part of the acquisition phase, the young subjects incorporated the inferred instrument into their memory for the acquisition sentence and were able to use the inferred instrument as a recall cue. The eleven-year-olds, on the other hand, were not only capable of inferring the instrument, but they did so automatically. This indicates that there is a developmental lag between acquiring the ability to perform an inference task and acquiring the tendency to make the inference spontaneously.

Barclay (Note 1) in an examination paper reported on an unpublished pilot study which employed inference sentences and non-inference sentences like those used by Bransford, Barclay, and Franks (1971). Barclay's subjects were six, eight, and eleven years of age.

Remembering was measured with a cloze test in which the children attempted to fill in the missing pronouns at the end of incomplete sentences read to them. Unlike the adult subjects in Bransford et al.'s study, none of the three age groups demonstrated differential recall of pronouns from the inference and non-inference sentences. One of the problems which this study did not examine was whether or not any of the age groups was capable of actually solving the inferences. In addition, Barclay did not report on the accuracy of the children's recall for the pronouns in general.

This review of the children's literature indicates that children are capable of semantic integration. Barclay and Reid (1974b) found that the children performed like adults on the recall of truncated passive sentences and that there was no significant difference between the five-year-olds and the ten-year-olds. Similarly, Paris and Mahoney (1974) reported that the pattern of recognition responses of eight-year-olds and ten-year-olds for the "original recognition sentences" was similar to adults'.

However, when it comes to the drawing of inferences and the recall of constructs, the picture is somewhat different. Much of the research on children's ability to draw inferences has been concerned with children's performance on tasks which explicitly require the subject to draw an inference and little attention has been paid to the question of whether children will spontaneously integrate information in order to draw an inference. Paris and Lindauer (1976) in exploring the performance of seven- to eleven-year-olds on the inferring and recall of instruments found that the eleven-year-olds, like the adults,

spontaneously inferred the instrument and incorporated the instrument into their memory representation of the sentence. The younger subjects, while capable of making the inferences, did not do so spontaneously. Therefore, it appears that there may be a developmental lag between the age at which a subject is capable of making an inference when required to do so and the age at which a subject draws an inference spontaneously.

The Experimental Problem

In their 1972 study, Bransford et al. presented adult subjects with sentences which embodied spatial inferences, like Sentence (1).

(1) Two robins were sitting on their nest and the eagle flew over them.

The research to be described in the following chapter had two purposes. The first was to assess the ability of six- and ten-year-old children to draw valid inferences from sentences like Sentence (1) above. The second goal was to demonstrate that there is a developmental lag between the age at which subjects are capable of drawing spatial inferences when the experimental task explicitly requires that they do so and the age at which subjects draw such inferences spontaneously.

Children's ability to draw spatial inferences. Spatial inference sentences such as Sentence (1) have a standard format. There is an actor (the eagle), an action (flying over), and two objects, related in some way, which are the recipients of the action (the robin and the nest). There is an explicit statement that one of the subjects was acted upon. The listener must infer that the other

object was also acted upon by virtue of the relationship between the two objects. In some respects, drawing an inference from sentences such as (1) is similar to solving a transitivity problem of the type: A > B, B > C, A?C. In a classical transitivity problem, the individual must integrate two pieces of information by making use of a common middle term. One can "translate" an inference item into the form of a transitivity problem. For example:

Potential inference sentence: Two robins were sitting on their nest and the eagle flew over them.

Inference question: Did the eagle fly over the nest?

"Two robins were sitting on their nest" = robins > nest

"The eagle flew over the robins" = eagle > robins

"Did the eagle fly over the nest?" = eagle ? nest

Drawing an inference of this type is similar to solving a transitivity problem in that both problems involve co-ordinating two pieces of information. One difference between the inference problem and the classical transitivity problem is that the inference problem can be written in such a way that it does not have a middle term. For example:

Potential inference sentence: Two robins were sitting on their nest and the eagle flew over it (the nest).

Inference question: Did the eagle fly over the robins?

"Two robins were sitting on their nest" = robins > nest

"The eagle flew over the nest" = eagle > nest

"Did the eagle fly over the robins?" = eagle ? robins

This is a transitivity problem with the middle term missing. If it

were a classical transitivity problem, one would have to conclude that eagle > robins, or robins > eagle, or even eagle = robins could be true. But, from one's knowledge of the real world, one knows that eagle > robins must be true.

As was previously mentioned, studies of children's ability to solve classical transitivity problems have indicated that children's performance on transitivity improves dramatically between the ages of six and ten. To the extent that spatial inference problems are like transitivity, one might expect a similar pattern of results; that is, six-year-olds would perform at or below the chance level and ten-year-olds would perform significantly better. However, these inference problems are more concrete than the transitivity task and the children should be able to draw upon their knowledge of the real world to help solve them. Consequently, the children may solve inference problems more easily than they would transitivity problems and the six-year-olds might score well above the chance level on the spatial inference problems.

Spontaneous drawing of inferences. One purpose of this research project was to demonstrate that there is a developmental lag between the age at which subjects are capable of drawing spatial inferences when the experimental task explicitly requires that they do so and the age at which they spontaneously draw such inferences. As was previously mentioned, Paris and Lindauer (1976) demonstrated that while six- and nine-year-old children were capable of inferring instruments, only the eleven-year-old subjects did so spontaneously. In Paris and Lindauer's study, the experimenters probed for the presence of the

implied instrument in the subject's memory representation of the acquisition sentence by providing the name of the instrument as a cue for sentence recall. However, there are other methods available for determining whether or not a subject has spontaneously drawn an inference, for example, the procedure used by Jenkins (1971). Jenkins presented adults with potential inference sentences and each potential inference sentence was followed by a direct question or an inference question. Jenkins reported that when there was no material interpolated between the potential inference sentence and the question about it, inference questions took significantly longer to answer than direct questions did. This indicated that, at the immediate point of comprehension, the subject's representation of the sentence did not include the inference. However, with 15 words of interpolated material (an interval of 7.5 seconds), the significant difference in latency between inference and direct questions disappeared. Therefore, during the interval between the presentation of the potential inference sentence and the question about it, the adult subject had spontaneously drawn the inference. Thus, the subject's memory representation of the sentence was in the form of a construct which included both the inferred information as well as the information given.

It was decided to employ a similar method in this research. Six- and ten-year-old children and adults were presented with potential inference sentences and each sentence was followed by a direct question or an inference question. The amount of interpolated material between the potential inference sentence and the question was varied. It was anticipated that the adult subjects would be proficient at

drawing inferences and furthermore that when material was interpolated between the potential inference sentence and the question, the adults' memory representation for the sentence would include both the direct and inferred information. (This spontaneous drawing of inferences on the part of the adults would be reflected in their latency scores; that is, with interpolated material there would be no significant difference in latency between inference and direct answers.)

On the basis of previous research with children in the area of inferences, two different predictions about the children's performance were possible. Both predictions incorporate the concept of a developmental lag between the age of acquisition of the ability to draw inferences and the age at which subjects do so spontaneously. On the one hand, children may treat the spatial inferences like classical transitivity problems. If this were the case, then the six-year-olds would perform at about the chance level on inference problems and would not demonstrate spontaneous inferencing. The ten-year-olds would solve the inference problems with a high degree of accuracy, but because the ability to draw inferences is a relatively recently acquired ability, the ten-year-olds would not show evidence of spontaneous inferencing.

On the other hand, it has been pointed out that the spatial inference problems are more concrete than classical transitivity problems and that perhaps the children could make use of their knowledge of the real world in solving these problems. In that case, the six-year-olds might be very successful at making inferences, but they would not draw the inferences spontaneously. In contrast, the

ten-year-olds would not only be proficient at drawing inferences, but also, would be making the inferences spontaneously.

CHAPTER II

THE RESEARCH

Experiment 1

A Preliminary Study with Children

The purpose of this study was to observe how six- and seven-year-old children interpret potential inference sentences. Although there has been a great deal of research on children's understanding of spatial prepositions (Ames, 1948; Carrow, 1968; Clark, 1973a; Harris, 1972), no work had been reported on children's ability to draw inferences from potential inference sentences which employ such prepositions. Specifically, this experiment was concerned with three questions. First, can six- and seven-year-old children draw spatial inferences from potential inference sentences? Second, when material is interpolated between the potential inference sentence and the question about it, will the representation of the potential inference sentence in the child's memory be in the form of a construct which includes both the information given and the inference? And third, will acting out the potential inference sentence with concrete objects encourage the child to draw the inference?

Sixteen potential inference sentences were created. Each potential inference sentence was embedded in a story, in order to maintain the children's interest in the task. In addition to the

16 potential inference stories, there were also 16 distractor stories. The 32 stories were presented to a total of 14 children, aged 6-0 to 7-4. After each child was tested, the experimenter examined the written protocol of the test session in order to determine in what ways the test procedure might be modified in order to provide the experimenter with more information about how the children were interpreting the potential inference sentences. Consequently, the wording of the questions which the experimenter asked the subject was changed more than once during this preliminary study. Therefore, the following presentation of method and results includes only that sub-sample of children who all heard the same type of questions.

METHOD

Subjects

The subjects were six children aged 6-0 to 7-4, with a mean age of 6-10. There were four boys and two girls.

Materials

The test material for the children consisted of 32 short stories. Each story was followed by two questions, a content question and a yes-no question. Sixteen of the thirty-two stories contained potential inference sentences (see Appendix I). The other 16 stories were distractors which were written in order to balance the number of "yes" and "no" questions (see Appendix II). The story frames containing the potential inference sentences consisted of three sentences: one 10-word sentence and two 15-word sentences. The potential

inference sentence could appear as either the second sentence in the story or the last sentence. Thus, either no material was interpolated between the potential inference sentence and the question (0 IM), or two 15-word sentences were interpolated (30 IM). An example of an item with no interpolated material is as follows:

First filler sentence: At Christmas Santa visited a house where good children lived.

Second filler sentence: The family used to leave some cookies and milk beside the Christmas tree for Santa.

Third filler sentence: Eight reindeer pulled Santa's sleigh and they stood on the roof and waited for Santa.

Potential inference sentence: Santa put some toys in his bag and brought them into the house.

Content question: Santa brought in what?

(child responds.)

Yes-no question: Did Santa bring in the (toys) (bag)?

(Child responds.)

An example of an item with 30 words of interpolated material is:

First filler sentence: At Christmas Santa visited a house where good children lived.

Potential inference sentence: Santa put some toys in his bag and brought them into the house.

Second filler sentence: The family used to leave some cookies and milk beside the Christmas tree for Santa.

Third filler sentence: Eight reindeer pulled Santa's sleigh and they stood on the roof and waited for Santa.

Content question: Santa brought in what?

(Child responds.)

Yes-no question: Did Santa bring in the (toys) (bag)?

(Child responds.)

A within-subject design was employed so that each child received eight potential inference items with 0 IM and eight with 30 IM.

Each story was followed by two questions. The first question, the content question, was designed to test the child's understanding of and memory for the information in the potential inference sentence. It was assumed that the child would probably answer the content question with the noun antecedent to the final pronoun in the sentence; that is, the child would give the direct answer to the question, rather than the inference answer. For example, the child might hear the sentence, "Santa put some toys in his bag and brought them into the house." This would be followed by the question, "Santa brought in what?" It was expected that the child would answer "toys". The second question would be about the inference, in this case, "Did Santa bring in the bag?"

However, on the basis of Bransford et al.'s (1971) research on adults' recall of potential inference sentences of this type, it was possible that the responses might be different when material was interpolated between the potential inference sentence and the question. If, after 30 words of interpolated material, the memory for the sentence is in a form which includes the inference, there should be an increase in the number of content questions which receive the inference answer. In the present example, the inference answer to the question, "Santa

brought in what?" would be "the bag". If the child gave this inference answer, the experimenter would then ask the direct question, "Did Santa bring in the toys?"

Procedure

The children were tested individually. There were three practice items followed by the 32 test items. After the first 16 items, there was a short break. Each child heard the following instructions:

> I am going to read you some short stories. After each story I will ask you some questions about the story. I have some small prizes here and if you do well in answering the questions, you can have one of them. First, we'll do three stories for practice so that you can see how it goes.

With four of the six subjects, after all 32 items had been presented, the potential inference items where the child had answered "no" to the yes-no question were repeated. If the child failed the item after it had been repeated, the experimenter gave the child a set of small toys representing the objects described in the potential inference sentence. The potential inference sentence was read again, while the child acted out the sentence with toys. The content question and the yes-no question were then repeated.

At the end of the experimental session the child received a small prize. The entire session took about 40 minutes.

RESULTS AND DISCUSSION

Number of Direct and Inference Responses

As was explained in the Procedure, when the child gave a direct answer to a content question, he was asked the yes-no inference question. Since there were 60 direct answers to the content questions, there were 60 yes-no inference questions asked. Similarly, if a child gave an inference answer to a content question, he was then asked the yes-no direct question. Since there were 28 inference answers given to content questions, there were 28 yes-no direct questions asked. Table 3 shows the distribution of responses to the two types of questions. As Table 3 indicates, 47 out of 60 yes-no inference questions (78.3%) were answered correctly and 23 out of 28 yes-no direct questions (82.1%) were answered correctly.

Another method of assessing children's ability to draw inferences is to add the number of inference responses given to content questions and the number of "yes" responses given to yes-no inference questions, in order to arrive at a combined inference score. Since there were 28 inference responses given to content questions and 47 "yes" responses given to yes-no inference questions, the total number of inference responses was 75, or a mean of 12.5 inference responses per subject, out of a possible 16 (78.2%). Similarly, one may add the number of direct responses given to content questions and the number of "yes" responses given to yes-no direct questions, for a combined direct score. There were 60 direct responses given to content questions and 23 "yes" answers to yes-no direct questions; therefore, the number of direct responses was 83, or a mean of 13.8 (86.4%). For each

TABLE 3

The Distribution of Responses to Content and Yes-No Questions

Response to Content Question		
Direct	Inference	Don't Know
60	28	8

Response to Yes-No Inference Question		Response to Yes-No Direct Question	
Yes	No	Yes	No
47	13	23	5

subject, an inference proportion was calculated. The numerator in the inference proportion was the number of inference responses the subject gave. The denominator was the number of inference responses plus the number of direct responses. If the subject gives the same number of inference responses as direct, then the inference proportion = $x/2x$ = .5. The mean of the inference proportions was .47 (SD = .03) and this was significantly less than .5, t = 2.37, p = .05. Therefore, whether one considers only responses to yes-no questions or responses to content questions and yes-no questions, it appears that the children's understanding and recall of the direct content was less than perfect and that performance on the direct content was better than on the inference content.

The Effect of Interpolated Material on Answers to Content Questions

A second point of interest in this study was whether or not the representation of the sentence in memory would change when material was interpolated between the potential inference sentence and the content question. Altogether, there were 96 content questions and answers. There were three types of answers to the content questions. These were: direct answers, inference answers, and "don't know". Table 4 shows the distribution of these three types of answers according to amount of interpolated material. Over all, the number of content questions receiving direct answers was 60 out of 96 (62.5%) and the number of questions with inference answers was 28 (29.2%). The number of "don't know" responses was eight (8.3%).

TABLE 4

The Distribution of Direct, Inference, and Don't Know Answers to Content Questions as a Function of Amount of Interpolated Material

Answer Type	Amount of Interpolated Material	
	0 Words	30 Words
Direct	26	34
Inference	20	8
Don't Know	2	6

There were 48 content questions where no material was interpolated between the potential inference sentence and the question. With no interpolated material, the number of direct answers was 26 out of 48 (54.2%) and the number of inference answers was 20 (41.7%). With 30 words of interpolated material, direct answers increased to 36 out of 48 (70.8%) and the number of inference answers decreased to 8 (16.7%). There was an increase in "don't know" responses with increasing interpolated material from two (4.2%) at 0 IM to six (12.5%) at 30 IM, indicating increased forgetting with increasing interpolated material.

Despite the fact that children did draw inferences, they did not tend to give more inference answers to content questions after 30 words of interpolated material than with no interpolated material. In fact, there was a decrease in inference answers to content questions with increased interpolated material. Thus, it appears that the six-year-olds in this preliminary study, unlike the adult subjects in Bransford et al.'s (1972) study, were not deriving their answers from constructs which included the inference.

Acting Out Potential Inference Sentences

As was explained in the Procedure, with four of the six subjects, the failed potential inference items were repeated. If the child failed the item again, the experimenter gave the child a set of toys representing the objects described in the potential inference sentence. The potential inference sentence was read again and the child acted out the sentence with the toys. Of the 16 items which

these four subjects failed on the first try, 12 were inference and four were direct. On the second presentation, six of the twelve inference items were failed and one of the four direct items was failed. Thus, there were seven potential inference sentences to be acted out. Three of these seven items were passed after the subject had acted them out and four were failed. The seven protocols are presented here, beginning with the three items which were passed after being acted out.

Protocol 1

First Presentation of Item

Potential inference sentence: Two fairies were sitting on a daisy and the giant stepped over it.

Content question: The giant stepped over what?

Child's answer to content question: The fairies.

Yes-no (direct) question: Did the giant step over the daisy?

Child's answer to the yes-no (direct) question: No.

Second Presentation

(As above)

Third Presentation

The experimenter gives the child a paper daisy and two plastic figures. The experimenter instructs the child to place the figures on the daisy and to do what the giant does when the sentence is read. The child acts out the sentence correctly.

Experimenter: Now, giant, what did you step over?

Child: The fairies.

Experimenter: Did you step over anything else?

Child: The daisy.

Protocol 2

First Presentation

Potential inference sentence: Two robins were sitting in their nest and the eagle flew over it.

Content question: The eagle flew over what?

Child's answer: The nest.

Yes-no (inference) question: Did the eagle fly over the robins?

Child's answer: The nest.

Second Presentation

Potential inference sentence: Two robins were sitting in their nest and the eagle flew over it.

Content question: The eagle flew over what?

Child's answer: The nest.

Yes-no (inference) question: Did the eagle fly over the robins?

Child's answer: No.

Third Presentation

The experimenter gives the child a nest, two robins, and an eagle and asks the child to act out the sentence while it is being read.

Content question: What did the eagle fly over?

Child's answer: The birds with the nest in. The nest with the birds in.

Yes-no (inference) question: Did the eagle fly over the robins?

Child's answer: Yes, with the nest.

Protocol 3

First Presentation

Potential inference sentence: Some people were standing at the bus-stop and the bus went past them.

Content question: The bus went past what?

Child's answer: By the puddle of water and splashed them.

Yes-no (inference) question: Did the bus go past the bus-stop?

Child's answer: No.

Second Presentation:

Potential inference sentence: Some people were standing at the bus-stop and the bus went past them.

Content question: The bus went past what?

Child's answer: The people.

Yes-no (inference) question: Did the bus go past the bus-stop?

Child's answer: No.

Third Presentation

The experimenter gives the child a bus, some figures, and a bus-stop and asks the child to act out the sentence while it is being read. The child acts out the sentence correctly.

Experimenter: The bus went past what?

Child: The people. And the bus-stop.

It has been pointed out that inference problems involve co-ordinating two pieces of information: the relationship between the actor and the direct noun and the relationship between the direct noun and the inference noun. If the child is having difficulty

co-ordinating the two relationships expressed in the potential inference sentence, then one might expect that acting out the sentences with objects would improve performance, since the relationships between the actor, the direct noun, and the inference noun should be immediately apparent. Acting out the sentences did result in inference answers in Protocols 1, 2, and 3. (In Protocol 1, it appears that the child initially attributed the wrong noun to the pronoun "it" and then failed to draw the inference until he acted out the situation.)

In the four protocols that follow, acting out the potential inference sentence did not automatically result in the child's giving an inference answer. In two of these four protocols (Protocols 4 and 5) the experimenter eventually prompted the child to give an inference answer by pointing out the relationship between the direct and inference nouns. In the other two cases (Protocols 6 and 7), the children persisted in their non-inference responses.

Protocol 4

First Presentation

Potential inference sentence: Some hunters got into a boat and it sailed across the lake.

Content question: What sailed across the lake?

Child's answer: The boat.

Yes-no (inference) question: Did the hunters sail across the lake?

Child's answer: No.

Second Presentation

(As above)

Third Presentation

The experimenter gives the child a boat and two figures and instructs the child to act out the sentence while it is being read. The child acts out the sentence correctly.

Content question: What sailed across the lake?

Child's answer: The boat.

Yes-no (inference) question: Did the hunters sail across the lake?

Child's answer: No.

Fourth Presentation

The experimenter instructs the subject to act out the sentence while it is being read.

Experimenter: Where are the men sitting?

Child: In the boat.

Experimenter: What is the boat doing?

Child: Sailing across the lake.

Experimenter: Are the men sailing across the lake?

Child: Yes.

Protocol 5

First Presentation

Potential inference sentence: A woman was sitting in her car and the fire-truck rushed past it.

Content question: The fire-truck rushed past what?

Child's answer: The car.

Yes-no (inference) question: Did the fire-truck rush past the woman?

Child's answer: No.

Second Presentation

(As above)

Third Presentation

The experimenter gives the child a car, a truck, and a figure and asks the child to act out the sentence while it is being read. The child acts out the sentence correctly.

Content question: The fire-truck rushed past what?

Child's answer: The car.

Yes-no (inference) question: Did the fire-truck rush past the woman?

Child's answer: No.

Fourth Presentation

The experimenter takes the toys and acts out the sentence, while asking the following questions.

Experimenter: Where is the woman sitting?

Child: In the car.

Experimenter: And where is the fire-truck going?

Child: Past the car.

Experimenter: Is the fire-truck going past the woman?

Child: Yes.

In Protocols 4 and 5, when the child acted out the sentence, he did not give an inference answer until the experimenter prompted him to notice the spatial relationships between the objects. For

six- and seven-year-olds, at least, the manipulation of the objects described in the potential inference sentence may not guarantee that the child will become aware of the relationships between the objects that he is manipulating.

Protocol 6

First Presentation

Potential inference sentence: A boy was sitting in front of the television and his mother walked in front of it.

Content question: The mother walked in front of what?

Child's answer: The television.

Yes-no (inference) question: Did the mother walk in front of the boy?

Child's answer: No.

Second Presentation

(As above)

Third Presentation

The experimenter gives the child a toy television set and two dolls and instructs the child that the sentence will be read again and that he is to make the figures do what the sentence says. The experimenter reads the potential inference sentence and the child positions the articles correctly.

Content question: The mother walked in front of what?

Child's answer: The T.V.

Yes-no (inference) question: Did the mother walk in front of the boy?

Child's answer: No.

Fourth Presentation

The experimenter reads the potential inference stence while the child acts it out.

Experimenter: Where is the mother walking?

Child: In front of the T.V.

Experimenter: Is the mother walking in front of the boy?

Child: No.

Protocol 7

First Presentation

Potential inference sentence: The king was sitting on his throne and the prince was standing beside it.

Content question: The prince was standing beside what?

Child's answer: The throne.

Yes-no (inference) question: Was the prince standing beside the king?

Child's answer: No.

Second Presentation

(As above)

Third Presentation.

The experimenter gives the child a throne and two figures and asks the child to act out the sentence while it is being read. The child acts out the sentence correctly, with the king sitting on his throne and the prince standing on the floor beside the throne.

Content question: The prince was standing beside what?

Child's answer: The throne.

Yes-no (inference) question: Was the prince standing beside the king?

Child's answer: No. If he was standing beside the king, he would be standing here. (The child stands the prince on the throne beside the king.)

Protocols 6 and 7 illustrate that children may interpret a crucial preposition differently from the way the adult experimenter does. Clark (1973a) has reported that children have difficulty understanding the various meanings of "in front of". This may explain why the subject in Protocol 6 did not give an inference answer even after acting out the sentence twice. Because of the apparent ambiguity of the prepositions "beside", "in front of", and "at", it was decided that the three items that employed these prepositions would not be used in future studies and three new items were written to replace them.

In summary, this initial study indicated that children were capable of drawing valid inferences, at least some of the time. It appeared that during the interval provided by the 30 words of interpolated material, the children were not spontaneously restructuring the information in the potential inference sentence to form a construct which included both the direct and inferred information. And finally, it was observed that manipulating the objects described in the potential inference sentence did not always lead the child to draw the inference.

Experiment 2

This research project was concerned with demonstrating that there is a developmental lag between the age at which subjects are capable of drawing spatial inferences from potential inference sentences and the age at which they do so spontaneously. In Experiment 2 adult subjects were tested. The adults were to furnish norms to which the children's performance could be compared. It was expected that the adult subjects would be highly proficient at drawing inferences. Furthermore, when a delay was imposed between the potential inference sentence and the question about it, the adults would draw the inference spontaneously during the interval and the adults' memory representation for the sentence would contain both the information directly stated in the sentence and the inference.

In some respects the experimental procedure which was to be employed was similar to that used by Jenkins (1971). However, in the present series of experiments the task had to be suitable for both adults and children; therefore, there were some differences between the material which Jenkins used and the material which was used in the present study. In the first place, the potential inference sentences which Jenkins employed always used a pronoun at the end of the sentence to refer to the N_1 or N_2. For example, one of Jenkins' items was: "The children sat on the swing and their mother stood beside (them) (it)." In Experiments 2, 3, and 4 in the present study, instead of a pronoun, a noun was used to refer to the N_1 or N_2; for example, "Santa put some toys in his bag and brought the (toys) (bag) into the house." The use of the noun instead of the pronoun was

expected to make the task easier for the children, since the results of Experiment 1 seemed to indicate that on occasion the six-year-olds were misinterpreting the final pronoun in the potential inference sentence.

In the second place, the interpolated material which was used in this study was different from Jenkins'. Jenkins' interpolated material consisted of one or two 15-word sentences which were not related to the potential inference sentence. Thus, an item consisted of a string of unrelated sentences followed by the question about the potential inference sentence. It was apparent that children would quickly become bored and unco-operative if they were required to listen to such items. In addition, items composed of unrelated sentences would be hard for children to remember. Therefore, the potential inference sentences were imbedded in stories, with the restriction that the N_1 and N_2 were to be mentioned only in the potential inference sentence.

The interpolated material used in Experiments 2, 3, and 4 of the present study differed from that used by Jenkins in another respect, as well. In Experiment 1 of the present study the 30 IM condition was obtained by interpolating two 15-word sentences between the potential inference sentence and the question about it. (This was like Jenkins' 30 IM condition except, of course, that in Experiment 1 the two 15-word sentences were part of a story.) In Experiment 1 it was noted that when the amount of interpolated material was increased from zero words to 30, there was a slight increase in the number of "don't know" responses to the content question about the

potential inference sentence. This result suggested that with an increase in amount of interpolated material there was increased forgetting of the potential inference sentence. Therefore, it seemed desirable to employ some type of interpolated material which would minimize forgetting of the potential inference sentence. Consequently, in Experiments 2, 3, and 4 the 30 IM condition was replaced by a 24 IM condition consisting of one 15-word sentence and one 9-word question. The advantage of the 9-word question was that it would fill the delay interval (and prevent the subject from rehearsing the material he had already heard) while not providing the subject with more information to be remembered; that is, the filler question must be remembered only long enough for the subject to answer it. Bjork (1972) in studies of directed forgetting has demonstrated that this type of situation does not produce retroactive inhibition.

METHOD

Subjects

The subjects were 46 Summer School students at the University of Western Ontario. There were 20 males and 26 females.

Materials

Sixteen potential inference sentences were used. Of these, 13 were the same sentences which had been written for use in Experiment 1 and three were new sentences. The amount of material between the potential inference sentence and the question about it was varied. Each potential inference sentence was placed in a story

frame consisting of one 10-word sentence and one 15-word sentence. The story was followed by two questions. One question, of course, referred to the potential inference sentence. The other question was a filler question about some other part of the story. In the zero words of interpolated material (0 IM) condition, the potential inference sentence was followed immediately by the question about it. In the 24 words of interpolated material condition (24 IM), the potential inference sentence was followed by one 15-word sentence and the 9-word filler question. In the 24 IM condition, the time elapsed between the end of the potential inference sentence and the beginning of the question about that sentence was approximately 17 seconds. Two examples follow:

0 Words of Interpolated Material (Inference Item)

First filler sentence: A boy was going away to visit his grandparents' farm.

Second filler sentence: The boy's father told him to be a good boy and gave him some money.

Potential inference sentence: His mother packed some clothes in a suitcase and gave the suitcase to the boy.

Question about potential inference sentence: Quickly now: Did the mother give the boy the clothes?

(Subject responds)

Question about filler sentence: Next question: Was the boy going away to visit the zoo?

(Subject responds)

24 Words of Interpolated Material (Inference Item)

First filler sentence: A boy was going away to visit his grandparents' farm.

Potential inference sentence: His mother packed some clothes in a suitcase and gave the suitcase to the boy.

Second filler sentence: The boy's father told him to be a good boy and gave him some money.

Question about filler sentence: Quickly now: Was the boy going away to visit the zoo?

(Subject responds)

Question about potential inference sentence:

Next question: Did the mother give the boy the clothes?

(Subject responds)

Since there were four possible sentence-question combinations (N_1N_1, N_2N_2, N_1N_2, and N_2N_1) and two levels of interpolated material (0 IM and 24 IM), there were eight possible item forms (N_1N_1 - 0 IM, N_2N_2 - 0 IM, N_1N_2 - 0 IM, N_2N_1 - 0 IM, N_1N_1 - 24 IM, N_2N_2 - 24 IM, N_1N_2 - 24 IM, and N_2N_1 - 24 IM). Four of the eight forms are inference items and four are direct items. A within-subject design was used so that each subject received each of the eight forms. Since there were 16 items and only eight item forms, each subject received each item form twice. So that item form would not be confounded with item content, eight lists were constructed, with each item appearing in a different form on each list. (The 16 potential inference items are in Appendix III.)

The 16 stories of interest were combined with 24 filler stories to give a set of 40 stories. These filler stories were more complex than the filler stories that would be used with children. It was expected that the more difficult filler stories would prevent the adults' attention from wandering and would camouflage the experimental paradigm. In addition, the filler stories were used to balance the number of "yes-no", "no-yes", "yes-yes" and "no-no" answers that the subject would be giving to the two questions. (The filler stories are in Appendix IV.)

Procedure

The eight story lists were recorded on the right channel of a Sony stereo tape-recorder. There was a 5-second period of silence after each question in order to give the subject time to reply.

Each subject heard only one of the eight tape-recorded story lists. A table of random numbers was used to provide five different random orderings of the eight tape-recorded story lists. Thus, each of the story lists was presented once before moving on to the next random ordering of the eight lists. For reasons that will be explained later, six of the original 46 subjects were eliminated. Therefore, each list was presented to five subjects.

The subjects were tested individually. Two tape-recorders were used during the experimental session. The instructions and story list were played to the subject on the Sony tape-recorder. The subject listened to the tape-recording through mono earphones. Output from the Sony was fed into the right channel of a second tape-recorder, a

Tandberg. The left channel of the Tandberg received its input from a Tandberg microphone which was picking up the subject's answers. The experimenter monitored the questions and the subject's answers through the Tandberg's stereo earphones and made a tape-recording of the session.

Each subject heard the following tape-recorded instructions:

> This is an experiment about understanding English sentences. Here's how it works.
>
> You will hear some very short stories. After each story you will be asked two questions about the story you have just heard, and you are to answer 'yes' or 'no', whichever you think is right, to each question.
>
> I will be timing your answers, so please answer as quickly as you can when you hear the question. As well as answering quickly, you should try to answer correctly, of course.
>
> This material was prepared for use with ten-year-olds. Right now, I am collecting adult norms, that is, adult standards to be compared with the children's results. So, although the vocabulary may be simple, I would appreciate it if you would pay attention and do your best so that I can get a good idea of how adults perform on this task.
>
> Before we get started on the actual test material, we'll do some stories for practice so that you can see how it goes.
>
> I will read the story, and then ask a question. Answer 'yes' or 'no' as quickly as possible. Then I'll ask a second question about the same story, and once again you answer 'yes' or 'no' as quickly as possible. Remember that if you take too long to answer a question, the tape-recording will just go on to the next item.
>
> There is a small microphone in front of you. Please face the microphone at all times, so that it will pick up your voice when you answer.
>
> (There were four practice stories.)
>
> That was the last practice story. Do you have any questions?

After the subject had heard all the stories, he was interviewed to see if he had detected the experimental paradigm. It was assumed that if the subject began to anticipate that he might be asked an inference question, this would affect the latency of responses. Five subjects detected the experimental paradigm, and they were replaced by other subjects. One subject had to be replaced because of a tape-recorder malfunction.

When all the subjects had been tested, the tape-recordings were processed. Output from the right and left channels of the tape-recorder were passed through an amplifier to a filter which excluded all sounds below 100 cps and above 1,000 cps. The output from the filter was passed through a rectifier and from the rectifier into a Beckman polygraph. The polygraph provided a visual representation of the question, the subject's answer, and the silent period between the two. The paper speed was 25 mm per second. Thus, 1 mm of tracing represented .04 seconds. The latency of response was measured only for those items where the subject answered correctly (that is, "yes").

RESULTS AND DISCUSSION

Number of Correct Responses

The mean number of correct responses for each combination of item type and amount of interpolated material are shown in Table 5 and Figure 1. In each of the four conditions (direct item - 0 IM, direct item - 24 IM, inference item - 0 IM and inference item - 24 IM), the maximum number of correct responses is four.

TABLE 5

Mean Number of Correct Responses by Adults as a Function of Item Type and Amount of Interpolated Material

Item Type		Amount of Interpolated Material	
		0 Words	24 Words
Direct	M	4.00	3.77
	SD	.00	.58
Inference	M	3.41	3.80
	SD	.71	.52

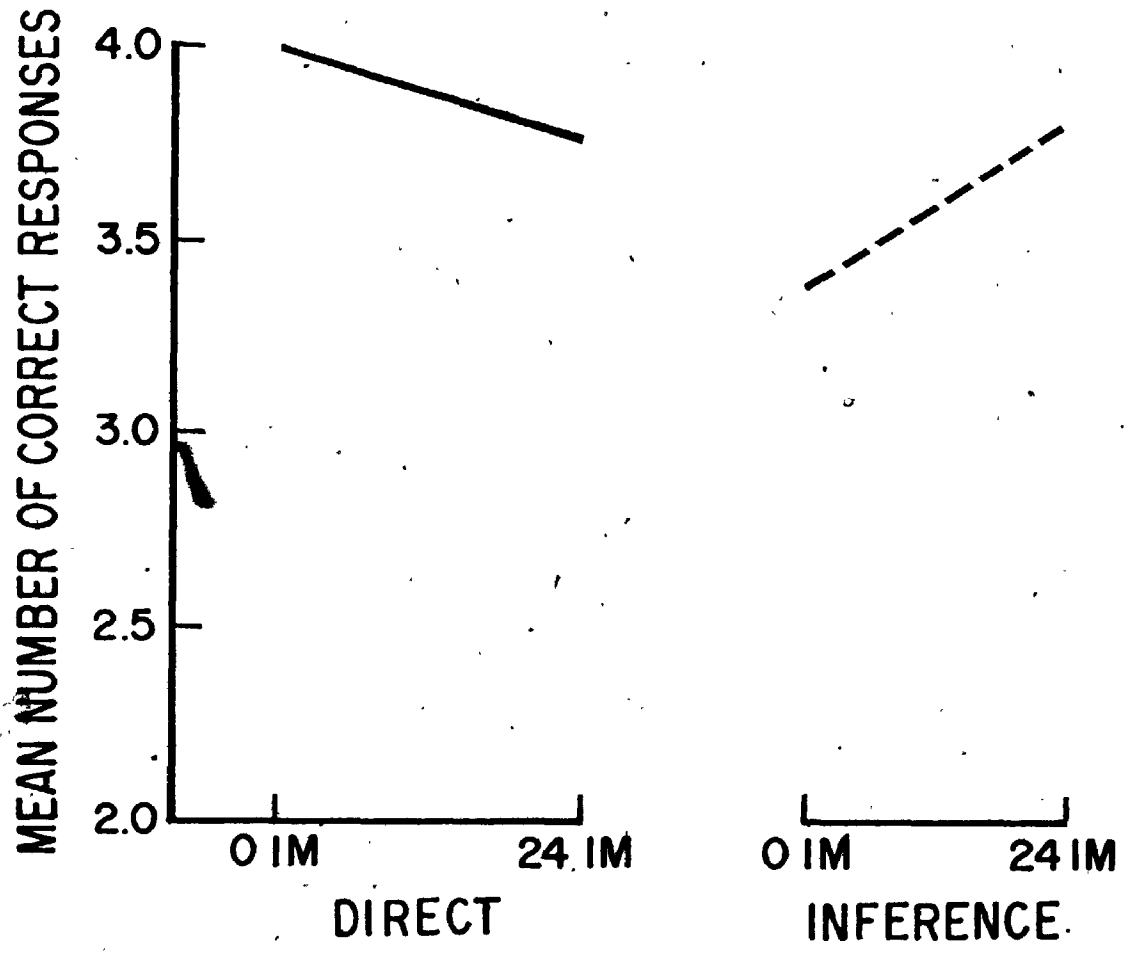

FIGURE 1. MEAN NUMBER OF CORRECT RESPONSES BY ADULTS AS A FUNCTION OF ITEM TYPE AND AMOUNT OF INTERPOLATED MATERIAL.

These data were subjected to an item type x amount of interpolated material repeated measures analysis of variance. In this analysis, as in subsequent analyses, item type was treated as a random factor, and appropriate quasi-F ratios (F') and degrees of freedom were calculated. This procedure follows suggestions made by Clark (1973b). When one treats item type as a random factor, one is suggesting that it should be possible to generalize from the results of this experiment to other studies which employ inference and direct items similar to, but not identical with, the items which were created for this study.

The analysis of variance revealed a significant item type effect, F (1, 39) = 12.35, $p < .01$, which indicates that more correct responses were made to direct items than to inference items. Amount of interpolated material had no significant main effect, F' (2, 1) = .11, $p > .25$. However, there was a significant item type x amount of interpolated material interaction, F (1, 39) = 22.26, $p < .01$. A post hoc Newman-Keuls test indicated that with zero words of interpolated material, the adults gave significantly more correct responses to direct items (M = 4.00) than to inference items (M = 3.40), q (2, 39) = 9.06, $p < .01$. With 24 words of interpolated material, there was no significant difference between the number of correct responses to direct items (M = 3.77) and inference items (M = 3.80).

Latency of Correct Responses

Four latency scores were calculated for each subject, one for each of the four conditions (direct item - 0 IM, direct item - 24 IM,

inference item - 0 IM, and inference item - 24 IM) by taking the mean of the latencies of the correct responses to the four items in that particular condition. Because of heterogeneity of variance between conditions, the latency scores were converted to the log of 1 + the latency score. The mean converted latency scores for each of the four conditions are shown in Table 6 and Figure 2.

A 2-factor (item type x amount of interpolated material) repeated measures analysis of variance was performed on these data. The main effect of item type was significant, F (1, 39) = 39.39, $p < .01$, indicating that inference items took significantly longer to answer than direct items. Amount of interpolated material had no significant main effect, F' (4, 1) = .17, $p > .25$. There was a significant item type x amount of interpolated material interaction, F (1, 39) = 7.19, $p < .05$. With no interpolated material, responses to inference items took significantly longer (M = .25) than responses to direct items (M = .17), q (2, 39) = 4.64, $p < .01$. With 24 words of interpolated material, there was no significant difference between the latency of responses to inference items (M = .23) and direct items (M = .19).

The latency scores and the number of correct responses reflect similar trends. When no material was interpolated between the potential inference sentence and the question, adult subjects gave more correct answers to direct items than to inference items and the mean latency of the correct responses to direct items was faster than the mean latency of responses to inference items. With 24 words of interpolated material there was no significant difference between

TABLE 6

Mean Converted Latency of Correct Responses by Adults as a Function of Item Type and Amount of Interpolated Material

Item Type		Amount of Interpolated Material	
		0 Words	24 Words
Direct	M	.17	.19
	SD	.05	.06
Inference	M	.25	.23
	SD	.07	.07

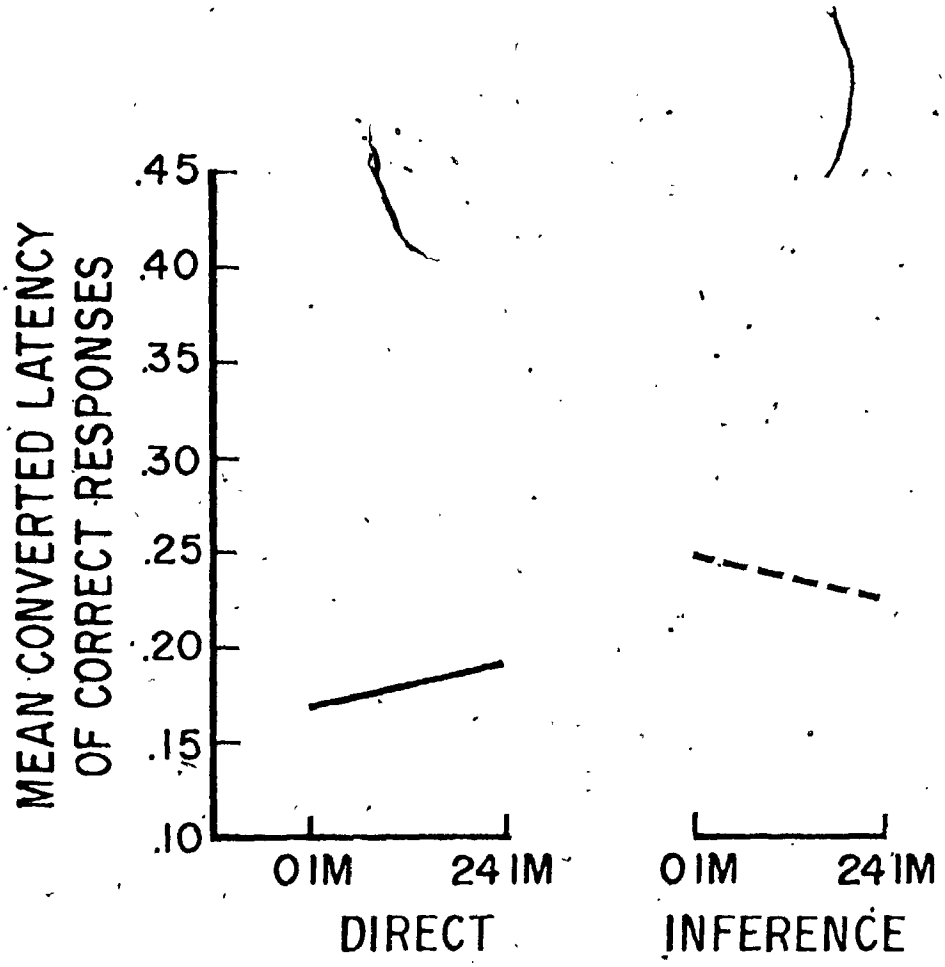

FIGURE 2. MEAN CONVERTED LATENCY OF CORRECT RESPONSES BY ADULTS AS A FUNCTION OF ITEM TYPE AND AMOUNT OF INTER-- POLATED MATERIAL.

direct and inference items either in the number of correct responses or in the latency of correct responses.

The results of this study support the hypothesis offered by Jenkins (1971). Jenkins suggested that when an adult subject hears a potential inference sentence which is followed immediately by an inference question, the subject must actively restructure the information contained in the potential inference sentence in order to arrive at the inference. This restructuring process takes time. Hence, both Jenkins' and the present study found that, with no interpolated material, inference questions take significantly longer to answer than direct questions. However, if there is a delay imposed between the presentation of the potential inference sentence and the question, the information in the potential inference sentence is restructured during the delay and a construct is formed such that the inference and direct answers are equally accessible to the subject. If the inference and direct answers are equally accessible, then there should be no difference between response times to inference and direct questions. The work of Bransford et al. (1972) indicated that when three minutes were allowed to elapse between the potential inference sentence and the question, the subject's memory representation of the sentence was in the form of a construct. Jenkins found that the difference in response latencies to the two kinds of questions disappeared after 15 words of interpolated material (approximately 7.5 seconds). The present study found no significant difference in response times after 24 words of interpolated material (approximately 17 seconds) even though in this study the direct noun was mentioned twice. Thus, with

Bransford et al.'s spatial type of inferences, even less than three minutes is sufficient for the formation of a construct.

Experiment 3

In Experiment 3 six- and ten-year-old children were presented with the same potential inference items that the adult subjects in Experiment 2 had received. Six-year-olds and ten-year-olds were chosen because, as was indicated in the Introduction, these are "landmark" ages in the development of classical transitivity, and spatial inferences seem to be formally similar to transitivity problems. If spatial inferences are like transitivity problems, then the six-year-olds might perform at only a chance level. On the other hand, to the extent that spatial inferences involve one's knowledge of the "real world" (that is, are less abstract than transitivity problems), perhaps the six-year-olds would do better on these problems than they do on transitivity problems. It was expected that the ten-year-old subjects would be proficient at drawing spatial inferences.

In research with adult subjects, it has been shown that when a delay is imposed between the presentation of the potential inference sentence and the question about it, the adults restructure the information contained in the potential inference sentence and derive the inference. On the one hand, it was possible that the ten-year-old subjects would perform like the adults in this respect. On the other hand, there could be a lag between the age at which children acquire the ability to make an inference and the age at which they do so spontaneously. Therefore, it was also possible that when material

was interpolated between the potential inference sentence and the question the ten-year-olds, despite their proficiency at drawing inferences, would not spontaneously restructure the information in the potential inference sentence to arrive at the inference.

METHOD

Subjects

The subjects were Grade One and Grade Five pupils at two London elementary schools. There were 39 Grade Ones, with a mean chronological age of 6-11. There were 41 Grade Fives, with a mean chronological age of 10-10.

Materials

The verbal materials used were similar to those used with the adult subjects in Experiment 2. The 16 stories containing the potential inference sentences and the questions about these stories were the same as for the adult subjects (see Appendix III).

As with the adults, there were two levels of interpolated material, zero words and 24 words. Since there were two levels of interpolated material and four sentence-question combinations (N_1N_1, N_2N_2, N_1N_2 and N_2N_1), there were eight item forms (N_1N_1 - 0 IM, N_2N_2 - 0 IM, N_1N_2 - 0 IM, N_2N_1 - 0 IM, N_1N_1 - 24 IM, N_2N_2 - 24 IM, N_1N_2 - 24 IM and N_2N_1 - 24 IM). Four of the eight forms were inference items and four were direct items. A within-subject design was used so that each child received each of the eight item forms twice. In order that item form not be confounded with item content, there were eight lists

constructed, with each item appearing in a different form in each list..

The 16 potential inference stories were combined with 16 filler stories to give a set of 32 stories. These filler stories were simpler than the filler stories that were used with adults and served to balance the number of "yes-no", "no-yes", "yes-yes", and "no-no" answers that the child would be giving to the two questions. (The filler stories from Experiment 3 are contained in Appendix V.)

Procedure

The children were tested individually. The stories and questions were played to the subject on a Sony tape-recorder. The experimenter recorded the questions and the child's answers on a Tandberg tape-recorder.

The experimenter read the following instructions:

> To-day you're going to hear some tape-recorded stories and answer some questions about them. You see I have two tape recorders here. This one is for you to listen to and this one is for me. In a minute, you can put on these ear-phones, like this (experimenter demonstrates) and listen to the tape-recording.
>
> You are going to hear some little stories and after each story the tape-recording will ask you two questions about the story. When you hear the first question, you should answer 'yes' or 'no', whichever is right, as fast as you can. When you hear the second question, you should answer 'yes' or 'no', whichever is right, as fast as you can. Then the tape-recording will go on to the next story.
>
> You see that there's a small microphone here. I'm going to tape-record your answers, so I want you to face the microphone.
>
> Now I'm going to turn on the tape-recorder. The first four stories and questions are for practice so that you can see how it goes.
>
> Remember now, you are going to hear a little story followed by two questions. When you hear the first question, answer

'yes' or 'no', whichever is right, as fast as you can. When you hear the second question, answer 'yes' or 'no', whichever is right, as fast as you can.

Following the first 16 stories there was a 3-minute break. At the end of the experimental session, each child received a small prize. The entire session took approximately 45 minutes.

The tape-recordings from the experimental session were processed by passing the output from the left and right channels of the Tandberg tape-recorder through an amplifier and a rectifier into a Beckman dynograph. The dynograph provided a visual representation of the question and answer and the silent period between the two. The speed of the dynograph paper was 125 mm per second so that the latency of response was measured to the nearest .008 seconds.

RESULTS AND DISCUSSION

Number of Correct Responses

The mean number of correct responses for each of the four conditions (direct item - 0 IM, direct item - 24 IM, inference item - 0 IM, and inference item - 24 IM) for the six-year-olds and ten-year-olds is shown in Table 7 and Figure 3. A 3-factor (item type x amount of interpolated material x age) repeated measures analysis of variance was performed on these data.

The effect of item type was significant, F (1, 48) = 76.19, $p < .01$. The direct items received more correct answers (M = 3.63) than the inference items (M = 2.73). Amount of interpolated material had no significant main effect, F' (58, 1) = .11, $p > .25$. However, there was a significant interaction between item type and amount of

TABLE 7

Mean Number of Correct Responses by Children as a Function of Item Type and Amount of Interpolated Material

Age		Amount of Interpolated Material	
		0 Words	24 Words
Six Years			
Direct Items	M	3.69	3.21
	SD	.61	.98
Inference Items	M	2.28	2.79
	SD	1.37	1.24
Ten Years			
Direct Items	M	3.82	3.78
	SD	.43	.46
Inference Items	M	2.90	2.94
	SD	1.28	1.14

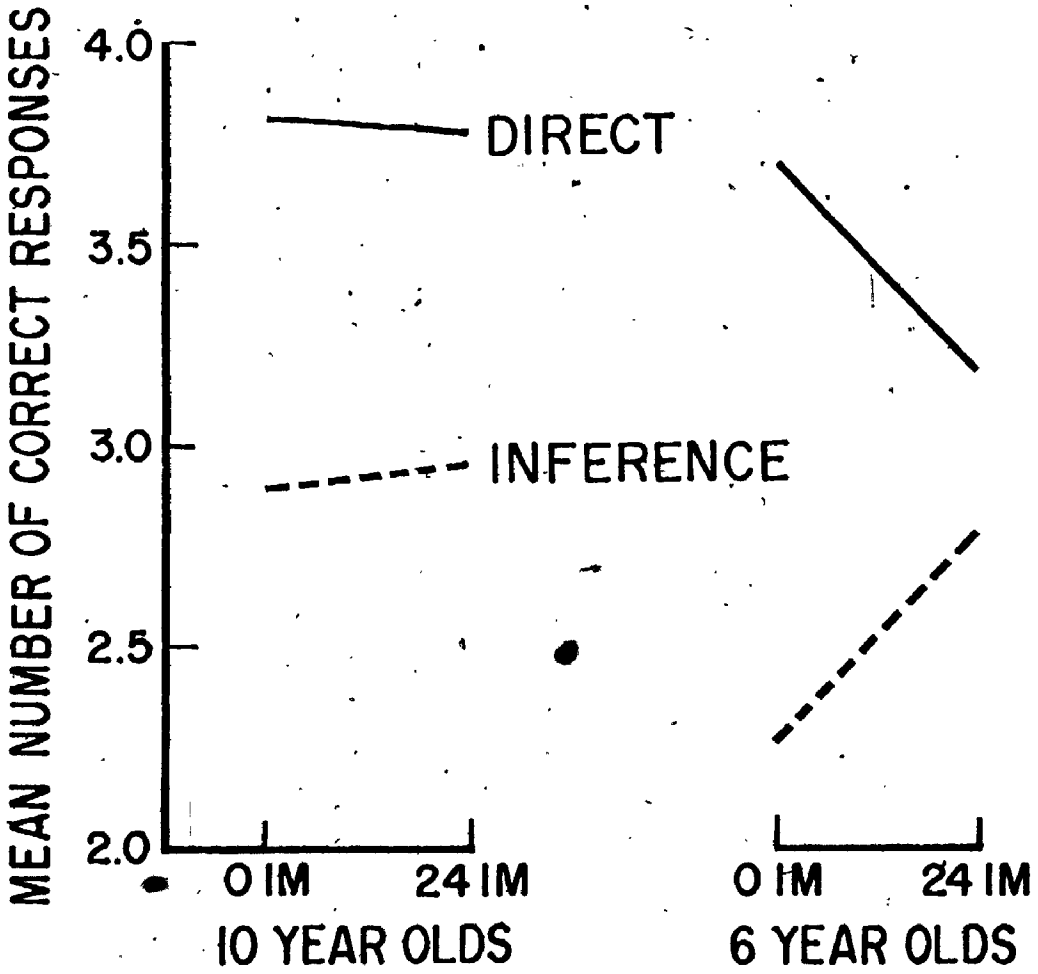

FIGURE 3. MEAN NUMBER OF CORRECT RESPONSES BY TEN–YEAR–OLDS AND SIX–YEAR–OLDS AS A FUNCTION OF AMOUNT OF INTERPOLATED MATERIAL AND ITEM TYPE.

interpolated material, F (1, 58) = 7.92, $p < .01$. The nature of this 2-way interaction can be interpreted by examining Figure 3. With the direct items, increasing the amount of interpolated material resulted in a decrease in the number of correct responses; with the inference items, increasing the amount of interpolated material resulted in an increase in the number of correct responses.

Age had a significant effect, F' (1, 28) = 7.11, $p < .01$. The ten-year-olds gave more correct responses (M = 3.36) than the six-year-olds (M = 2.99). There was a significant 3-way interaction between item type, amount of interpolated material, and age, F (1, 48) = 4.45, $p < .05$. Figure 3 indicates the nature of this 3-way interaction. With direct items, at zero words of interpolated material, the ten-year-olds made slightly more correct responses (M = 3.82) than the six-year-olds (M = 3.69) and this difference was not significant. Thus, with no interpolated material, both age groups understood and remembered the direct content of the sentences equally well. When the amount of interpolated material was increased to 24 words, the ten-year-olds gave a mean of 3.78 correct responses to direct items, while the six-year-olds gave a mean of 3.21 correct responses, and the difference between the two was significant, q (2, 80) = 11.99, $p < .01$. These results indicate that the ten-year-olds' memory for the direct content of potential inference sentences was much less susceptible to interference from interpolated material than the six-year-olds' memory was.

With inference items and no interpolated material, the ten-year-olds made significantly more correct responses (M = 2.90) than the six-year-olds did (M = 2.28), q (2, 80) = 12.84, $p < .01$. In fact,

since the maximum possible number of correct answers in this condition is four, the six-year-olds were performing very close to chance level. At 24 words of interpolated material, there was no significant difference between the mean number of correct responses given to inference items by the ten-year-olds (2.94) and the six-year-olds (2.79).

From Figure 3, it is apparent that the lack of significant difference between the scores of the ten-year-olds and the six-year-olds results from the fact that while the ten-year-olds' scores on inference items were relatively unaffected by the increase in interpolated material, the six-year-olds' scores on inference items increased with increasing interpolated material. This increase in the number of correct responses made by six-year-olds to inference items may be explained as follows. The low score of the six-year-olds on inference items with no interpolated material indicates that even when the content of the sentence was recalled, the six-year-olds had great difficulty with inferences, and, in fact, performed at about the chance level on these items. Furthermore, six-year-olds forgot a great deal of sentence content when material was interpolated between the sentence and the question, as indicated by the decrease in the number of correct responses to direct questions with increasing interpolated material. Considering the difficulty that six-year-olds had with inferences and their relatively poor memory, it seems unlikely that the increase in six-year-olds' inference scores with increasing interpolated material reflects a "real" increase in their ability to draw inferences. If, after a delay, the six-year-olds had forgotten much of the sentence content, when asked to answer "yes" or "no" to a

question, they may have given what they felt was a plausible answer to the question. If they were answering by plausibility, this would account for the increase in correct (or "yes") responses between inference items to 0 IM and inference items at 24 IM. In other words, for the six-year-olds, forgetting the verbal material and answering plausibly may lead to more "correct" inference answers than remembering the material and trying (unsuccessfully) to work out the inference.

Latency of Correct Responses

Four latency scores were obtained for each subject by calculating the mean of the latencies of the correct responses to the four items in each of the four conditions (direct item - 0 IM, direct item - 24 IM, inference item - 0 IM and inference item - 24 IM). Four of the ten-year-old subjects and six of the six-year-old subjects were eliminated, because they gave no correct answers in the inference item - 0 IM condition, thereby making it impossible to calculate a mean latency for correct answers for that condition. One of the six-year-old subjects was eliminated because he gave no correct answers in the direct item - 24 IM condition. As with the adult subjects, the latency scores were converted to the log of 1+ the latency score. The mean converted latency scores for the six-year-olds and the ten-year-olds are shown in Table 8 and Figure 4. A 3-factor (item type x amount of interpolated material x age) repeated measures analysis of variance was performed on these scores.

The effect of item type was significant, F' (1, 31) = 60.41, $p < .01$. The latency of correct responses to direct items (M = .30)

TABLE 8

Mean Converted Latency of Correct Responses by Children as a Function of Item Type and Amount of Interpolated Material

Age		Amount of Interpolated Material	
		0 Words	24 Words
Six Years			
Direct Items	M	.29	.38
	SD	.11	.13
Inference Items	M	.41	.40
	SD	.16	.12
Ten Years			
Direct Items	M	.23	.29
	SD	.09	.10
Inference Items	M	.34	.35
	SD	.11	.13

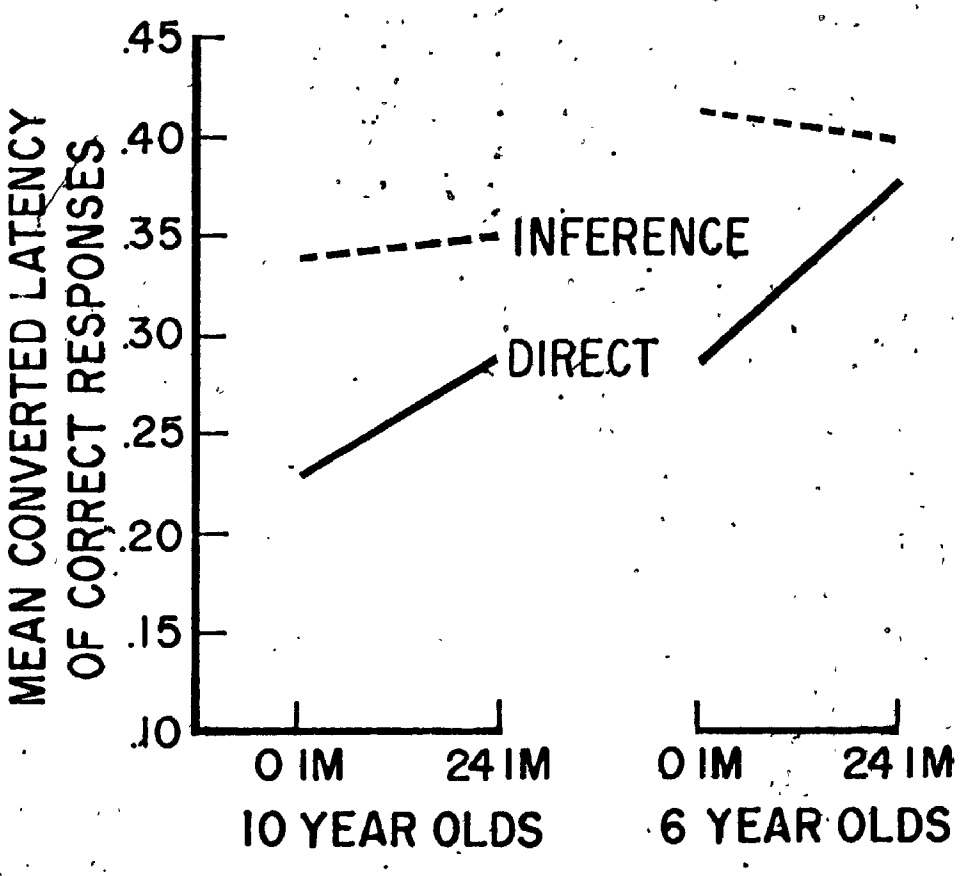

FIGURE 4. MEAN CONVERTED LATENCY OF CORRECT RESPONSES BY TEN–YEAR–OLDS AND SIX–YEAR–OLDS AS A FUNCTION OF AMOUNT OF INTERPOLATED MATERIAL AND ITEM TYPE.

was faster than the latency of correct responses to inference items (M = .39). This result parallels the finding that more correct answers were given to direct items than to inference items.

The age variable had a significant effect, F' (1, 32) = 9.93, $p < .01$. The latency of the ten-year-olds' responses (M = .30) was shorter than the latency of the six-year-olds' (M = .37). Thus, not only did the ten-year-olds give more correct responses than the six-year-olds, but they also responded more quickly.

Amount of interpolated material had no significant main effect, F' (1, 1) = 1.23, $p > .25$. There was, however, a significant interaction between item type and amount of interpolated material, F (1, 31) = 15.81, $p < .01$. Figure 4 illustrates the effect of interpolated material on latencies of inference and direct items at each age level. First, consider the scores of the ten-year-old subjects. With zero words of interpolated material, inference items took longer to answer than direct items, and this difference was significant, q (2, 31) = 11.72, $p < .01$. This difference in latency reflects the time that is required to work out the inference in order to answer the inference question correctly. With 24 words of interpolated material, inference items took significantly longer to answer than direct items, q (2,31) = 7.01, $p < .01$. If, after 24 words of interpolated material, the ten-year-olds were recalling a construct such that the direct and inference answers were equally available, there would be no significant difference between the latencies of correct responses to direct and inference items. This was the case with the adult subjects in Jenkins' study and in Experiment 2. However, the ten-year-olds do

show a significant difference between the latencies of responses to direct and inference items at 24 IM. Therefore, it may be concluded that the ten-year-olds are not working from constructs. Evidence from the number of items correct indicates that the ten-year-olds have good recall of verbal material after 24 words of interpolated material. Therefore, at 24 words of interpolated material, the ten-year-olds are recalling the sentence in its original form and working out the inference, and this accounts for the significant difference between the latencies of correct responses to inference and direct items with 24 words of interpolated material.

Next, consider the scores of the six-year-old subjects. With no interpolated material, inference items took significantly longer to answer than direct items, q (2, 30) = 7.025, $p < .01$. However, with 24 words of interpolated material, there was no significant difference between latencies to inference and direct questions. At first glance, it might appear that after 24 words of interpolated material, the six-year-olds, unlike the ten-year-olds, were recalling a construct and that this accounts for the absence of a significant difference between the latencies of direct and inference items. However, the pattern of correct responses must be taken into account when interpreting the latencies of correct responses. As was previously indicated, it is very likely that, after 24 words of interpolated material, the six-year-olds have forgotten much of the content of the potential inference sentence and the answers are arrived at by giving a plausible answer. It should take the same amount of time to answer an inference question plausibly as it does to answer a direct question,

and hence there is no significant difference between the latencies to the two types of questions.

Comparison of Children and Adults

Number of Correct Responses

Figure 5 shows the mean number of correct responses for each of the four conditions for the three age levels, adults, ten-year-olds and six-year-olds. A 3-factor (item type x amount of interpolated material x age) repeated measures analysis of variance was performed on the number of correct responses. The age variable had no significant main effect, F' (1, 4) = 3.72, $p > .25$. However, there was a significant age x item type interaction, F (2, 117) = 7.93, $p < .01$. Post hoc Newman-Keuls tests indicated that the adults and the ten-year-olds did not differ significantly in the number of correct responses given to direct items. However, the ten-year-olds gave significantly more correct responses to direct items than the six-year-olds did, q (2, 300) = 10.53, $p < .01$. Thus, the ten-year-olds understood and recalled the direct content of potential inference sentences as accurately as the adults did, but the six-year-olds did not perform as well as the ten-year-olds and adults.

However, adults gave significantly more correct responses to inference items than ten-year-olds did, q (2, 300) = 16.84, $p < .01$. Similarly, ten-year-olds answered inference items correctly significantly more often than six-year-olds did, q (2, 300) = 11.18, $p < .01$.

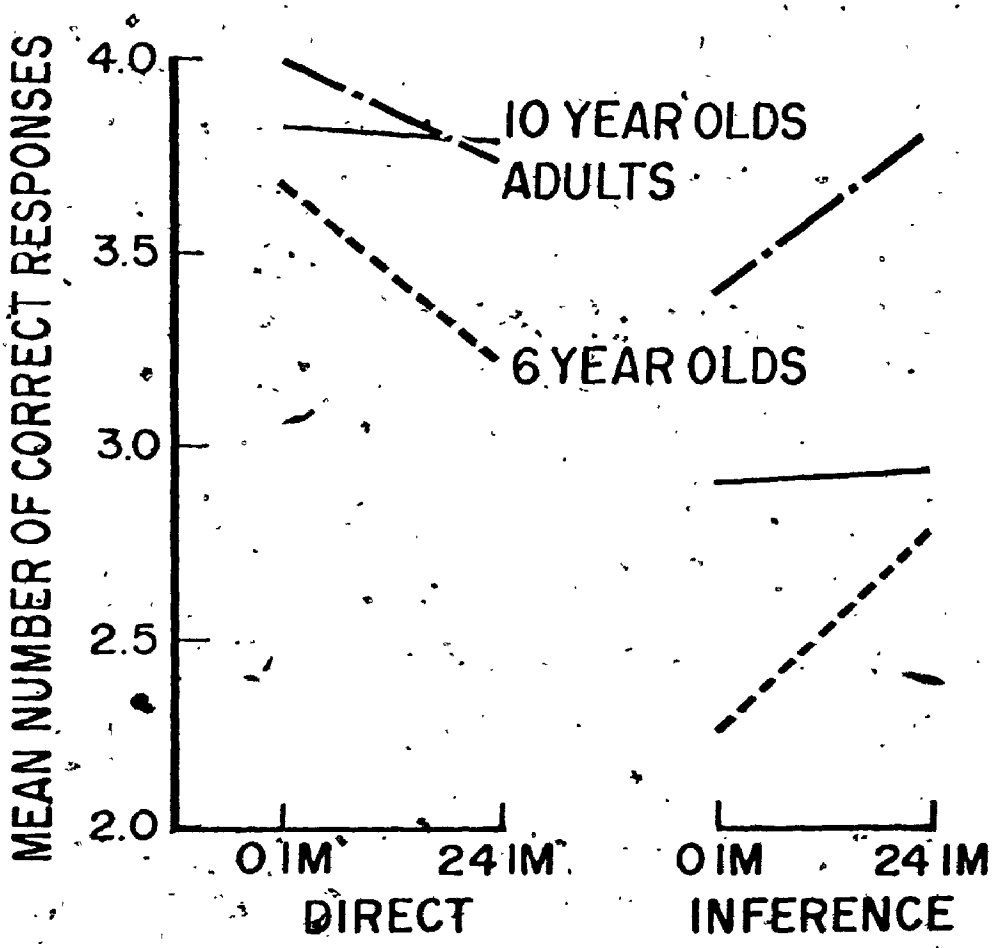

FIGURE 5: MEAN NUMBER OF CORRECT RESPONSES BY ADULTS, TEN-YEAR-OLDS AND SIX-YEAR-OLDS AS A FUNCTION OF ITEM TYPE AND AMOUNT OF INTERRELATED MATERIAL.

2 2

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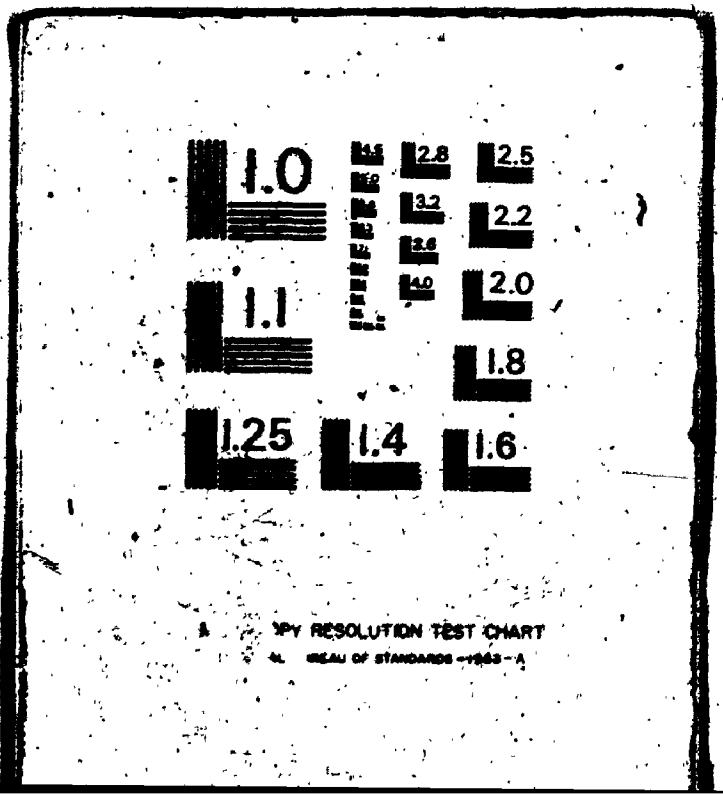
1.0
1.1
1.25
1.4
1.6
2.8
3.2
3.6
4.0
2.5
2.2
2.0
1.8
RESOLUTION TEST CHART
BUREAU OF STANDARDS-1963-A

Latency of Correct Responses

Figure 6 shows the mean converted latency of correct responses by adults, ten-year-olds, and six-year-olds. A 3-factor (item type x amount of interpolated material x age) repeated measures analysis of variance was performed on these scores. The age variable had a significant effect, $F'(2, 27) = 26.36$, $p < .01$. As Figure 6 indicates, adults responded faster than ten-year-olds, and ten-year-olds responded faster than six-year-olds. There was no significant interaction between age and item type. Thus, although ten-year-olds gave as many correct responses to the direct items as the adults did, the ten-year-olds took significantly longer to arrive at these correct answers.

General Discussion

The performance of the adults and children may be summarized as follows. The adult subjects understood and recalled the direct content of the potential inference sentences very well. With zero words of interpolated material, they made no errors on the direct items, and there was no significant decrease in the number of correct responses when the amount of interpolated material was increased to 24 words. The adults were proficient at drawing inferences; with no interpolated material, the mean number of correct inference answers was 3.4 out of a maximum possible of 4.0 (85%). When material was interpolated between the potential inference sentence and the question about it, the representation of the sentence in memory became a construct such that the inference and direct answers were equally accessible; therefore, there was no difference between the latencies of responses to inferences and direct questions.

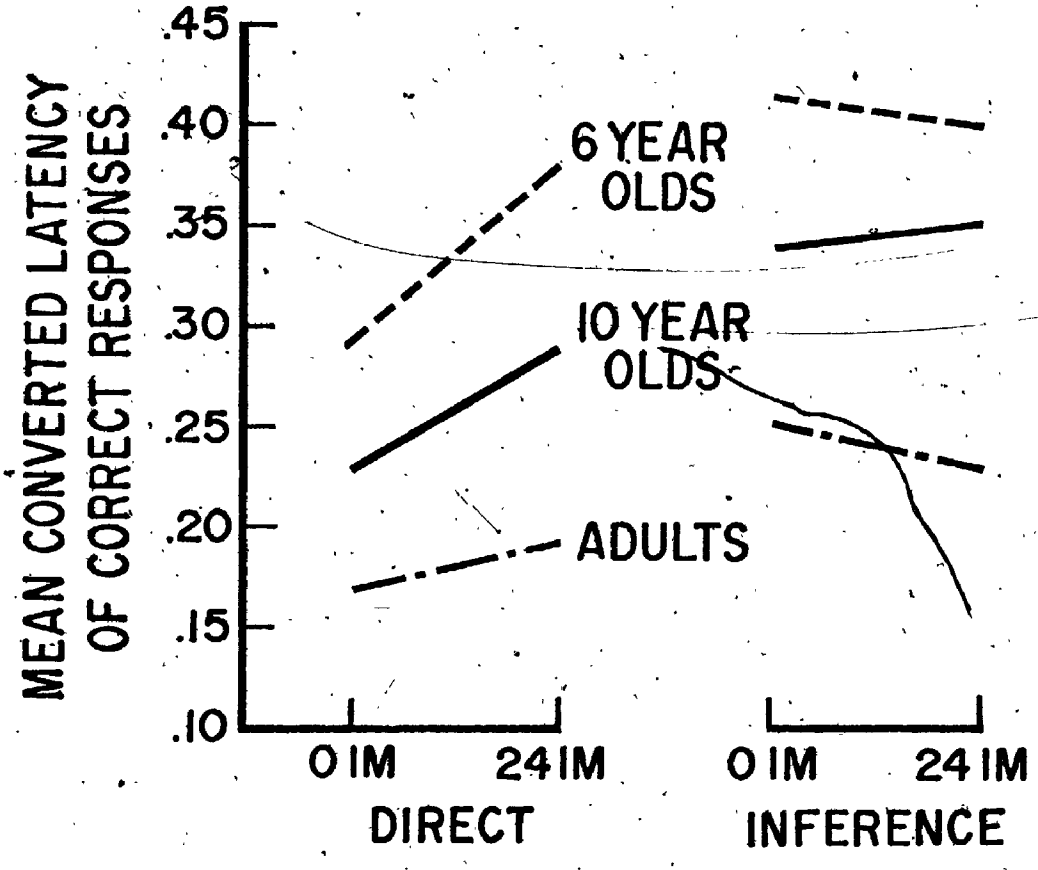

FIGURE 6. MEAN CONVERTED LATENCY OF CORRECT RESPONSES BY ADULTS, TEN–YEAR–OLDS AND SIX–YEAR–OLDS AS A FUNCTION OF ITEM TYPE AND AMOUNT OF INTERPOLATED MATERIAL.

The ten-year-old subjects were as proficient in answering direct questions as the adults were, although it took the ten-year-olds significantly longer to do so. Like the adults, the ten-year-olds had a good memory for verbal material and showed no significant decrease in correct answers with increasing interpolated material. The ten-year-olds, however, were not as proficient at drawing inferences as the adults were, and with no interpolated material, their mean number of correct inference answers was 2.90 (72.5%). When verbal material was interpolated between the potential inference sentence and the question, the ten-year-olds appeared to be working from the original sentence content rather than from a construct including both direct and inference answers as evidenced by the fact that inference answers took significantly longer than direct answers.

The six-year-old subjects did not differ significantly from the ten-year-olds in the number of correct responses to direct questions with no interpolated material, although the younger children took significantly longer to arrive at the correct answer than the older children did. However, the six-year-olds' memory for sentence content was disrupted by the interpolated material and at 24 words of interpolated material, the six-year-olds gave significantly fewer correct responses to direct items than the ten-year-olds did. The six-year-olds were not as proficient at drawing inferences as either the ten-year-olds or adults were. With no interpolated material, the mean number of correct inference answers given by six-year-olds was 2.28 (57%). It was concluded that, after 24 words of interpolated material, the six-year-olds were using the same process

to arrive at answers to direct and inference questions. Unlike the adults, however, this process did not involve a construct which contained both the direct and inference answers. Instead, the common process involved forgetting of the sentence content and giving a plausible response.

One final point to be discussed is the comparison of children's performance on spatial inference items and classical transitivity problems. There are two methods of evaluating the children's performance on a task. One is to consider the percentage of subjects in each age group who respond to a better-than-chance level. The other is to examine the percentage of correct responses at each age level. The number of correct answers at zero words of interpolated material was used for computing the two performance measures, since, at zero words of interpolated material, the effect of memory load is at a minimum. There were four inference items at 0 IM, and hence, a better-than-chance level of success would be three or four items right. With the six-year-olds, 53.8% of the subjects got three or four items right, while 72.5% of the ten-year-olds performed at a better-than-chance level. Similarly, 57% of the six-year-olds' responses and 72.5% of the ten-year-olds' responses were correct. Thus, the two measures of performance were congruent. These results are similar to those obtained for classical transitivity items. It would therefore appear that despite the fact that these inference items were less abstract than transitivity problems, the inference items were not easier to solve.

Experiment 4

In Experiment 3, it was reported that the six-year-old subjects performed at about chance level when there was no material interpolated between the potential inference sentence and the inference question. With the six-year-olds, the number of correct (that is, "yes") responses increased when material was interpolated between the potential inference sentence and the inference question. However, with the ten-year-old subjects, interpolating material between the potential inference sentence and the question did not change the number of correct answers to inference questions.

It was suggested that when material was interpolated between the potential inference sentence and the question, the six-year-olds forgot much of the information contained in the sentence and consequently gave what they considered a plausible answer and that this accounted for the apparent increase in the number of correct answers which occurred with interpolated material. On the other hand, the ten-year-olds were relatively good at drawing inferences and had a good memory for verbal material. When material was interpolated between the potential inference sentence and the question, the ten-year-olds processed the sentence the same way as they did when there was no interpolated material.

The experimental paradigm which requires the subject to answer "yes" or "no" is useful when response latencies are being measured. On the other hand, since a subject can answer "yes" or "no" to a question even when he has forgotten the material to which the

question refers, the yes-no question may not be the best method for determining what a subject really knows about the sentence. Therefore, it would seem logical to conduct a study in which the subjects are asked content questions (that is, questions which must be answered by naming an object) as well as yes-no questions. It was hoped that the results from this experiment would support the interpretation offered for the results of the preceding experiment.

METHOD

Subjects

The subjects were Grade One and Grade Five pupils at two London elementary schools. One of the two schools was the same as in Experiment 3. There were 20 Grade Ones, 11 boys and 9 girls, with a mean chronological age of 6-5. The six-year-olds had a mean Peabody IQ of 118.45, with a SD of 13.08. There were 20 Grade Fives, eight boys and twelve girls, with a mean chronological age of 10-8. The ten-year-olds had a mean Peabody IQ of 119.55, with a SD of 13.74.

Materials

The verbal material was similar to that used in Experiment 3. There were 16 potential inference sentences of the type:

Santa put some toys in his bag and brought the (toys) (bag) into the house.

There are two possible ways of writing each potential inference sentence. In the N_1 sentence, the first noun in the noun pair toys-bag is repeated at the end of the sentence. In the N_2 potential

inference sentence, the second noun in the noun pair is repeated.

N_1 Potential inference sentence: Santa put some toys (N_1) in his bag (N_2) and brought the toys (N_1) into the house.

N_2 Potential inference sentence: Santa put some toys (N_1) in his bag (N_2) and brought the bag (N_2) into the house.

Each potential inference sentence was embedded in a story frame consisting of two other sentences. As in Experiment 3, there were two levels of material interpolated between the potential inference sentence and the first question about it, zero words of interpolated material and 24 words. Since there were two ways of writing a potential inference sentence (N_1 or N_2) and two levels of interpolated material (0 IM and 24 IM), four different item forms were possible (N_1 sentence - 0 IM, N_1 sentence - 24 IM, N_2 sentence - 0 IM, and N_2 sentence - 24 IM). There were 16 potential inference stories, the same ones used in Experiment 3 (see Appendix III).

In order to avoid confounding story content with item form, four lists of stories were constructed so that a given story appeared in a given form in each list. Each subject heard only one story list. Within each age level, there were five subjects per list.

There were three questions about each potential inference sentence, a content question, a probe question, and a yes-no question. The nature of these questions can best be explained by an example.

Sequence 1

Potential inference sentence: Santa put some toys in his bag and brought the toys into the house.

Content question: What did Santa bring in?

The content question always began with the words "what did" and was neutral in the sense that it allowed the child to give either the direct noun (in this case "toys") or the inference noun ("bag") as the answer.

Child's answer to content question: Toys.

In this example, the child names the direct noun "toys" in answer to the content question. This answer indicated that he remembers the direct noun "toys" and that he understands that the toys were brought into the house.

Probe question: What were the toys in?

The probe question is asked in order to determine if the child can recall the other noun in the noun pair "toys" - "bag". The form of the probe question obviously has to vary with the child's answer to the content question. In other words, if the child had said "bag" in answer to the content question, the probe question would have to be, "What was in the bag?" in order to determine if the child could recall the noun "toys".

Child's answer to probe question: Bag.

In this example, the child names the inference noun "bag". This answer indicates that he remembers the inference noun "bag", but it does not indicate that he has necessarily drawn the inference that

the bag was brought in along with the toys. This distinction must be made, because the answer "bag" was given to the question "What were the toys in?" and not to the question "What did Santa carry in?" Now that it has been established that the child recalls the bag, we are ready to determine if he has drawn the inference, by asking the yes-no inference question.

Yes-no (inference) question: Did Santa bring in the bag?

Child's answer to the yes-no (inference) question: Yes.

The child's answer indicates that he has drawn the inference.

The information that was gained from this series of questions and answers may be summarized as follows. From the answer to the content question, we know that the child recalled the direct noun and that it was the recipient of the action of the verb. From the answer to the probe question, we know that the child recalled the inference noun. The answer to the yes-no question indicates that the child understood that the inference noun also was the recipient of the action of the verb; that is, that the child drew the inference.

The preceding example is only one of a number of possible sequences of questions and answers. The remaining sequences and their interpretation are presented in somewhat less detail in the following pages.

Sequence 2

Potential inference sentence: Santa put some toys in his bag and brought the bag into the house.

Content question: What did Santa bring in?

Child's answer to content question: Toys.

Probe question: What were the toys in?

Child's answer to probe question: Bag.

Yes-no (inference) question: Did Santa bring in the bag?

Child's answer to yes-no (inference) question: No.

The answer to the content question indicates that the child has recalled the direct noun and understands that it was the recipient of the action of the verb. The answer to the probe question indicates that the child recalls the inference noun. The answer to the yes-no inference question shows that the child has not drawn the inference.

Sequence 3

Potential inference sentence: Santa put some toys in his bag and brought the toys into the house.

Content question: What did Santa bring in?

Child's answer: Bag.

Probe question: What was in the bag?

Child's answer: Toys.

Yes-no (direct) question: Did Santa bring in the toys?

Child's answer: Yes.

The answer to the content question shows that the child has recalled the inferenee noun and that the child understands that the inference noun was the recipient of the action of the verb (that is, the child has made the inference). The answer to the probe question indicates that the child recalls the direct noun. The answer to the yes-no direct question shows that the child understands that the direct noun was the recipient of the action of the verb.

Sequence 4

Potential inference sentence: Santa put some toys in his bag and brought the toys into the house.

Content question: What did Santa bring in?

Child's answer: Bag.

Probe question: What was in the bag?

Child's answer: Toys.

Yes-no (direct) question: Did Santa bring in the toys?

Child's answer: No.

The answer to the content question shows that the child has recalled the inference noun and that the child has drawn the inference. The answer to the probe question indicates that the child recalled the direct noun. The answer to the yes-no direct question indicates that the child did not understand or has forgotten that the direct noun was the recipient of the action of the verb.

Sequences 1, 2, 3, and 4 share the common property that the child recalls both the direct noun and the inference noun (or synonyms of them). Thus, in these sequences, the child's answer to the yes-no question may be considered an "informed" answer as opposed to a guess. In Sequences 5, 6, and 7, the child forgets either the direct noun, or the inference noun, or both, and thus his answer to the yes-no question will be a product of guessing or some other similar process.

Sequence 5

Potential inference sentence: Santa put some toys in his bag and brought the toys into the house.

Content question: What did Santa bring in?

Child's answer: Toys.

Probe question: What were the toys in?

Child's answer: I don't know (or some other incorrect answer).

Yes-no (inference) question: Did Santa bring in the bag?

Child's answer: Yes (or no).

The child's answer to the content question shows that the child has recalled the direct noun and understands that the direct noun is the recipient of the action of the verb. The answer to the probe question shows that he has forgotten the inference noun. Consequently, the answer to the yes-no question is not an "informed" answer.

Sequence 6

Potential inference sentence: Santa put some toys in his bag and brought the toys into the house.

Content question: What did Santa bring in?

Child's answer: Bag.

Probe question: What was in the bag?

Child's answer: I don't know (or some other incorrect answer).

Yes-no (direct) question: Did Santa bring in the toys?

Child's answer: Yes (or no).

The answer to the content question shows that the child has recalled the inference noun and has drawn the inference. The answer

to the probe question indicates that the child cannot recall the direct noun.

Sequence 7

Potential inference sentence: Santa put some toys in his bag and brought the toys into the house.

Content question: What did Santa bring in?

Child's answer: I don't know (or some other incorrect answer).

This type of answer was followed by the yes-no direct question and the yes-no inference question presented in a random order. The answer to the content question indicates that the child has forgotten both the direct and the inference nouns.

In addition to the 16 potential inference stories, there were also 16 distractor stories with questions. (These distractor items are in Appendix VI.) Nine of these distractor items were the same as in Experiment 3 and seven were new items.

Procedure

The children were tested individually. In order to standardize the presentation of stories from subject to subject, the stories were tape-recorded. After each story the tape-recorder was stopped and the experimenter asked the sequence of questions. At the beginning of the experiment, the following instructions were read:

> Now what we're going to do-to-day is: you're going to listen to some little stories and answer some questions about the stories. The stories are all on the tape-recorder. This other tape-recorder is for tape-recording your answers.
>
> You are going to hear some little stories and after each story, I will ask you some questions about the story. After you've

answered the questions, I'll play another story on the tape-recorder.

I have some prizes with me and if you pay attention and do your best, you can choose one for yourself when we're all finished.

Now I'm going to turn on the tape-recorder. The first four stories and questions are for practice so that you can see how it goes.

Following the first 16 stories, there was a 3-minute break. At the end of the session, each child chose a small prize. The entire session took one hour.

RESULTS AND DISCUSSION

In this experiment, the sequence of questions about the potential inference sentence began with a content question, that is, a question that could be answered either by the direct or inference noun. Consequently, the inference-direct distinction became a dependent variable; in other words, a characteristic of the subject's response, rather than an independent variable manipulated by the experimenter. Therefore, item type was not a factor in the analysis of variance performed on the response data, and the number of direct responses was considered separately from the number of inference responses.

Direct Responses

The number of direct responses which the subject made to content questions (as in Sequences 1, 2, and 5) was added to the number of informed "yes" responses to yes-no direct questions (as in Sequence 3) in order to arrive at the combined number of direct

responses a subject made. Table 9 shows the mean number of these direct responses as a function of age and amount of interpolated material. Within each combination of age level and amount of interpolated material, the maximum possible number of responses is eight.

A 2-factor (age x amount of interpolated material) analysis of variance was performed on the number of direct responses. Age had a significant main effect, F (1, 38) = 21.23, $p < .01$, with the ten-year-olds giving significantly more responses (M = 7.53) than the six-year-olds (M = 6.37). The ten-year-olds obviously had better recall of material than the six-year-olds did.

There was a significant main effect due to the amount of interpolated material, F (1, 38) = 5.14, $p < .05$. With zero words of interpolated material, the mean number of responses was 7.2 and with 24 words of interpolated material, the mean number of responses was 6.7. Increasing the amount of interpolated material produced significant forgetting. There was no significant interaction between age and amount of interpolated material, F (1, 38) = .05, $p > .25$.

Inference Responses

As was the case with direct responses, the combined number of inference responses was calculated for each subject by adding the number of inference answers given to the content questions (as in Sequences 3, 4, and 6) to the number of informed "yes" responses given to the yes-no inference questions (as in Sequence 1). Table 9 shows the mean number of inference responses as a function of age and amount of interpolated material.

TABLE 9

Mean Number of Direct and Inference Responses to Content and Yes-No Questions as a Function of Age and Amount of Interpolated Material

Response Type		Amount of Interpolated Material	
		0 Words	24 Words
Direct			
Six-Year-Olds	M	6.65	6.10
	SD	1.04	1.55
Ten-Year-Olds	M	7.75	7.30
	SD	.44	.66
Inference			
Six-Year Olds	M	4.75	4.40
	SD	2.13	1.85
Ten-Year-Olds	M	7.05	6.65
	SD	1.05	1.31

These data were subjected to a 2-factor (age x amount of interpolated material) analysis of variance. There was a significant main effect due to age, F (1, 38) = 27.82, $p < .01$, with the ten-year-olds giving significantly more inference answers than the six-year-olds. Amount of interpolated material did not have a significant effect, F (1, 38) = 1.76, $p > .10$. There was no significant age x amount of interpolated material interaction, F (1, 38) = .01, $p > .25$.

In part, the difference in the number of inference answers given by the older and younger subjects must be due to the superior recall that the older children have of the sentence material. However, differences in recall alone cannot account for the difference between the two age groups in inference responses. The mean number of direct responses given by six-year-olds was 6.37 and the mean number of direct responses given by ten-year-olds was 7.53, and the difference between these two means is 1.16. The mean number of inference responses given by six-year-olds and ten-year-olds was 4.57 and 6.85, respectively, and the difference between these two means is 2.28. Thus, there was a greater difference between the ten-year-olds and the six-year-olds on inference responses than on direct responses and this reflects both the ten-year-olds' better recall and their greater inferencing ability.

In order to demonstrate that the difference between the six-year-olds' and the ten-year-olds' inference scores could not be attributed entirely to the superior recall ability of the ten-year-olds, an inference proportion was calculated for each subject and comparisons were made between the six-year-olds' and the ten-year-olds' inference proportions. The numerator in this inference proportion was

the number of inference responses (to content and yes-no questions) and the denominator was the number of inference responses plus the number of direct responses. In considering the proportion of responses which were inference responses rather than the absolute number of inference responses, the difference between the two age levels in recall ability is taken into account.

The mean inference proportions for each age level at each level of interpolated material are shown in Table 10. As Table 10 indicates, the amount of interpolated material had no effect on the inference proportions; however, the ten-year-olds' inference proportions were larger than the six-year-olds'. At each level of interpolated material, the Mann-Whitney test was used to compare the six-year-olds' and ten-year-olds' inference proportions. Both at 0 IM and at 24 IM, the ten-year-olds' inference proportions were significantly larger than the six-year-olds', $p = .01$. Therefore, the ten-year-olds' ability to draw inferences was superior to the six-year-olds'.

General Discussion

Table 11 presents the percentage of inference answers given by the children in Experiments 3 and 4. Experiment 4 confirmed that the ten-year-olds performed significantly better than the six-year-olds on inference items. In addition, in both experiments, the ten-year-olds' inference scores did not improve significantly with increasing interpolated material. This is in contrast to the results obtained with adults in Experiment 2, in which the increase in interpolated material was accompanied by a significant increase in the number of correct

TABLE 10

Mean Inference Proportion for Responses to Content and Yes-No Questions as a Function of Age and Amount of Interpolated Material

Age		Amount of Interpolated Material	
		0 Words	24 Words
Six Years	M	.40	.41
	SD	.11	.07
Ten Years	M	.47	.47
	SD	.04	.06

TABLE 11

Percentage of Inference Answers in Experiment 3 and Experiment 4 as a Function of Amount of Interpolated Material

Age	Experiment 3[a]	Experiment 4[b]
Six Years		
0 IM	57.00%	59.37%
24 IM	69.75%	55.00%
Ten Years		
0 IM	72.50%	88.13%
24 IM	73.50%	83.13%

[a]Responses to yes-no questions.

[b]Responses to content questions and yes-no questions.

inference answers. This confirms the conclusion that the ten-year-olds, despite their relative proficiency at solving inference problems, did not do so spontaneously during the interval provided by the interpolated material.

In both Experiments 3 and 4, the six-year-olds performed at about the chance level at zero words of interpolated material. This level of performance is the same as the performance level of six-year-olds on transitivity problems. However, in Experiment 3, the inference scores of the six-year-olds increased with increasing interpolated material; in Experiment 4, the six-year-olds' inference scores did not increase with increasing interpolated material. It was suggested that the increase in the six-year-olds' inference scores in Experiment 3 did not represent a "real" increase in their ability to draw inferences, but was the result of some other process such as giving a plausible answer. In Experiment 4, uninformed answers to yes-no questions were discounted and the six-year-olds' inference scores did not increase with increasing interpolated material. This finding supports the conclusion that the increase observed in Experiment 3 was spurious.

Another point to be discussed is the difference in inference scores between the six-year-old children in Experiment 1 and the other six-year-old subjects in this study. Table 11 shows the percentage of inference answers given by six-year-olds in Experiment 3 and Experiment 4. For the subjects in Experiment 1, the mean inference score (responses to content questions plus answers to yes-no questions) at 0 IM was 6.83 out of eight (85.37%). At 30 IM, the mean inference score was 5.67 (70.87%).

On the one hand, the higher rate of inference responses by the six-year-olds in Experiment 1 may indicate that these subjects were actually better at drawing inferences than the other six-year-olds. The children who participated in Experiment 1 were the children of university faculty members and they might be expected to perform better on a verbal task than children from the general population. On the other hand, the higher inference scores of the children in Experiment 1 may have resulted from a difference between the potential inference sentences in Experiment 1 and the potential inference sentences in Experiments 3 and 4. In the potential inference sentences in Experiment 1, a terminal pronoun was used to refer to the direct noun, while in the other experiments the direct noun was repeated at the end of the sentence. When a terminal pronoun is used, the inference-direct distinction depends upon the child's attending to the pronoun and assigning to the pronoun the correct antecedent noun. The following sentence may serve as an example:

> Santa put some <u>toys</u> in his <u>bag</u> and brought <u>them</u> into the house.

In this example, the noun "toys" may be considered the direct noun and the noun "bag" the inference noun only if the child interprets the pronoun "them" as referring to "toys" and only to "toys". It is possible, for example, that the child could interpret "them" to refer to both the "toys" and the "bag" in which case, the sentence would contain two direct nouns and no inference noun. It is not a question of whether or not six-year-old children can make the distinction between singular and plural pronouns and between singular and plural nouns,

and correctly assign antecedent nouns to pronouns. Rather, the question is whether six-year-old children do consistently make these distinctions when listening to connected discourse.

Potential Inference Sentences

Data from Experiments 2 and 3 were used to determine how easily subjects could draw the inference presented in each particular potential inference sentence. (The potential inference sentences used in Experiments 2 and 3 are presented in Appendix I.) The degree of difficulty for each potential inference sentence was determined separately for each age group and the results were compared across age groups. For example, with the adult subjects in Experiment 2, any given potential inference sentence appeared as an inference item 20 times (10 times as inference - 0 IM and 10 times as inference - 24 IM). Therefore, in Experiment 2, the maximum possible number of correct inference answers a particular potential inference sentence could receive was 20. The potential inference sentences were rank ordered from the easiest (those receiving the most correct inference answers) to the hardest (those receiving the fewest correct inference answers). The rank orders of the potential inference sentences for the three age groups are shown in Table 12. There is some similarity across age levels in the rank orders of potential inference sentences. For example, Sentences 2, 3, 6, 12, and 14 are the five most difficult sentences at each age level.

When the six-year-olds' and ten-year-olds' responses are considered, it appears that, with one exception, the eight easiest

TABLE 12

Rank Order of Potential Inference Sentences from Easiest to Most Difficult for Six-Year-Olds, Ten-Year-Olds, and Adults

Six-Year-Olds		Ten-Year-Olds		Adults	
Potential Inference Sentence	Rank	Potential Inference Sentence	Rank	Potential Inference Sentence	Rank
1	1.5	13	1.5	4	3
5	1.5	16	1.5	7	3
13	3	5	3.5	9	3
7	4	15	3.5	15	3
11	6	11	5	16	3
15	6	7	6	1	8.5
16	6	1	7	5	8.5
9	8	9	8	8	8.5
10	9.5	4	9.5	10	8.5
4	9.5	10	9.5	11	8.5
8	11	8	11	13	8.5
12	12.5	3	12	6	12
14	12.5	14	13	12	13
3	14	6	14	14	14
2	15	2	15	2	15
6	16	12	16	3	16

potential inference sentences have a common feature, that is, that each sentence describes some change in the location (or ownership) of the direct and inference objects. The seven easy potential inference sentences which conform to this rule are:

(1) His mother packed some clothes in a box and gave the (clothes) (box) to the boy.

(5) Some men got into a boat and the (men) (boat) sailed across the lake.

(7) Her mother put some cookies on a plate and carried the (cookies) (plate) into the dining room.

(9) The boy filled his pail with nuts and took the (pail) (nuts) home.

(11) The mother was carrying a basket of eggs and she dropped the (basket) (eggs).

(13) Santa put some toys in his bag and brought the (toys) (bag) into the house.

(16) The teacher put three snails in a bottle and gave the (snails) (bottle) to a boy.

The one exception to the rule that the easiest potential inference sentences describe a change in the direct and inference objects is Sentence (15).

(15) Two robins were sitting on their nest and the eagle flew over the (robins) (nest).

The eight difficult potential inference sentences (with one exception) do not describe a change in the location of the direct and inference objects. The seven difficult potential inference sentences

which are no change sentences are:

(2) Two elves were sitting on a daisy and the giant stepped over the (elves) (daisy).

(3) Two frogs were sitting on a log and the fish swam around the (frogs) (log).

(6) Some caterpillars were hiding under a stone and the girl stepped over the (caterpillars) (stone).

(8) Some children were sitting in a tree and the toy airplane went past the (children) (tree).

(10) Some puppies were sleeping in a cage and the boy walked around the (puppies) (cage).

(12) Two racoons were sitting on a rock and the owl flew over the (racoons) (rock).

(14) A woman was sitting in a car and the fire-truck rushed past the (woman) (car).

The one exception to the rule that the most difficult sentences were no change sentences is Sentence (4).

(4) The man put some pennies in a box and buried the (pennies) (box) in the sand.

Despite the two exceptions to the rule that the easiest potential inference sentences are change sentences and the most difficult sentences are no change sentences, it was decided to incorporate the change- no change distinction in organizing the verbal material for Experiment 4. As in Experiments 2 and 3, each subject heard the eight change sentences and the eight no change sentences. However, in addition, the type of potential inference sentence (change or no change)

was crossed with sentence form (N_1 or N_2) and amount of interpolated material (0 IM or 24 IM) so that each subject received an equal number (that is, two) of the following items: N_1 - 0 IM - *change*, N_2 - 0 IM - *change*, N_1 - 24 IM - *change*, N_2 - 24 IM - *change*, N_1 - 0 IM - *no change*, N_2 - 0 IM - *no change*, N_1 - 24 IM - *no change*, and N_2 - 24 IM - *no change*.

In Experiment 4 the relationship between type of potential inference sentence and the number of direct answers was considered in addition to the relationship between sentence type and the number of inference answers. Table 13 shows the mean number of direct responses given by six-year-olds and ten-year-olds as a function of type of sentence and amount of interpolated material. With each combination of sentence type and amount of interpolated material, the maximum possible number of responses is four. A 3-factor (age x amount of interpolated material x potential inference sentence type) repeated measures analysis of variance was performed on the number of direct responses. As in the previous analysis, the age variable had a significant effect, F' (1, 39) = 20.67, $p < .01$, with ten-year-olds giving more direct answers than six-year-olds. Similarly, amount of interpolated material had a significant effect, F' (2, 14) = 3.79, $p < .05$, with more direct answers given at 0 IM than at 24 IM. For *change* sentences, the mean number of direct answers decreased from 3.53 at 0 IM to 3.37 at 24 IM. Similarly, for *no change* sentences, the mean number of direct answers at 0 IM and 24 IM were 3.67 and 3.40, respectively.

TABLE 13

Mean Number of Direct Responses by Six-Year-Olds and Ten-Year-Olds as a Function of Type of Potential Inference Sentence and Amount of Interpolated Material

Age		Sentence Type	
		Change	No Change
Six Years			
0 IM	M	3.30	3.35
	SD	.86	.81
24 IM	M	3.05	3.20
	SD	.99	1.06
Ten Years			
0 IM	M	3.75	4.00
	SD	.44	.00
24 IM	M	3.70	3.60
	SD	.47	.60

Sentence type did not have a significant main effect, F (1, 38) = .476, $p > .25$, and did not enter into any significant interactions. The mean number of direct responses following no change sentences was 3.54, while the mean number of direct responses following change sentences was 3.45. Therefore, it appears that the children understood and remembered the direct content of no change potential inference sentences as well as the direct content of the change sentences.

Table 14 shows the mean number of inference responses. A 3-factor (age x amount of interpolated material x sentence type) analysis of variance was performed on the number of inference responses. Age had a significant effect, F' (1, 7) = 16.58, $p < .01$ with the ten-year-olds giving more inference answers than six-year-olds. Amount of interpolated material did not have a significant main effect, F' (2, 1) = .36, $p > .25$.

The main effect of sentence type was significant, F (1, 38) = 28.22, $p < .01$. There were more inference answers following change sentences (M = 3.20) than following no change sentences (M = 2.55). There was also a significant interaction between sentence type and amount of interpolated material, F (1, 38) = 8.37, $p < .01$. For the change sentences, increasing interpolated material from zero words to 24 words resulted in a decrease in the mean number of inference answers from 3.47 to 2.93. However, with the no change sentences, an increase in interpolated material resulted in an increase in the mean number of inference responses from 2.47 at 0 IM to 2.63 at 24 IM. The age x sentence type interaction was not significant, F (1, 38) = 1.70, $p > .10$. Both six-year-olds and ten-year-olds were more

TABLE 14

Mean Number of Inference Responses by Six-Year-Olds and Ten-Year-Olds as a Function of Type of Potential Inference Sentence and Amount of Interpolated Material

Age		Sentence Type: Change	Sentence Type: No Change
Six Years			
0 IM	M	3.00	1.85
	SD	1.08	1.46
24 IM	M	2.50	2.00
	SD	1.00	1.08
Ten Years			
0 IM	M	3.95	3.10
	SD	.22	.91
24 IM	M	3.40	3.25
	SD	.68	.85

successful at drawing inferences from the change potential inference sentences than from the no change sentences.

It might be appropriate to consider the change which the easy potential inference sentences describe in terms of Bennett's (1975) concept of a "journey". A journey describes the source, path, and/or the goal of an action. In the present experiment, the easy sentences give an account of a journey made by the direct and inference objects while the hard sentences do not. In most of the easy sentences, the goal of the journey is specified. For example, in Sentence (7) the goal of the journey made by the "cookies" and "the plate" is the dining room.

(7) Her mother put some cookies on a plate and carried the (cookies) (plate) into the dining room.

In Sentence (5) the path of the journey ("across the lake") is indicated.

(5) Some men got into a boat and the (men) (boat) sailed across the lake.

In Sentence (11) the journey made by the "basket of eggs" is implied by the verb "dropped".

(11) The mother was carrying a basket of eggs and she dropped the (basket) (eggs).

The one easy sentence which does not describe a journey by the direct and inference objects is (15).

(15) Two robins were sitting on their nest and the eagle flew over the (robins) (nest).

In contrast to the easy sentences, the hard sentences do not describe a journey made by the direct and inference objects; instead, the hard sentences indicate the location of the direct and inference objects relative to each other; for example,

(2) Two elves were sitting on a daisy and the giant stepped over the (elves) (daisy).

In addition, it may be noted that the hard sentences concern a journey made by the actor and that the direct object is contained in a preposition phrase which describes the path of the journey. In Sentence (2) the actor ("the giant") moves along a path "over the (elves) (daisy)".

Sentence (4) may be the one hard sentence which does have the direct and inference objects making a journey.

(4) The man put some pennies in a box and buried the (pennies) (box) in the sand.

In (4) "the sand" could be considered the goal of a journey made by the "pennies" and the "box".

Another way of distinguishing between easy and hard potential inference sentences might be on the basis of the type of image evoked by the connective between the nouns referring to the direct and inference objects. Rohwer (1970) reported on a number of studies of paired-associate learning of nouns in which the form class of the connective between the nouns was varied. The number of correct responses was higher when the nouns were connected by a verb than when they were connected by a preposition or a conjunction. Rohwer suggests that the different types of connectives elicit different kinds of visual images. Verb connectives (e.g., "the shoe taps the chair") evoke an

action image of an event involving the two objects. Prepositions (e.g., "the shoe under the chair") and conjunctions (e.g., "the shoe and the chair") give rise to static images. The action imagery evoked by the verb connective is more memorable than the static imagery of the prepositions and conjunctions (Paivio, 1971, p. 388).

In six of the easy potential inference sentences, the direct and inference objects are linked by an action, for example:

(7) Her mother put some cookies on a plate . . .

(9) The boy filled his pail with nuts . . .

The two exceptions to the rule for easy potential inference sentences are Sentence (11) and Sentence (15).

(11) The mother was carrying a basket of eggs . . .

(15) Two robins were sitting on their nest . . .

Sentence (15) is like the hard potential inference sentences in that in the hard potential inference sentences the direct and inference objects are linked by a description of their location relative to each other, which is essentially a static description, for example,

(8) Some children were sitting in a tree . . .

(10) Some puppies were sleeping in a cage . . .

The one exception to this rule for hard potential inference sentences is (4) in which the "pennies" and the "box" are connected by the action of putting one into the other.

(4) The man put some pennies in a box . . .

Since the present study was not primarily concerned with distinguishing between easy and hard potential inference sentences, the analysis of the differences between potential inference sentences

is admittedly post hoc. However, subsequent studies could explore the problem systematically. For example, one could vary the nature of the relationships between the direct object and the inference object and between the direct object and the actor. The content of potential inference sentences is a relevant variable to be considered in studies of children's drawing of inferences, in particular, in those studies which attempt to determine why children have difficulty in making inferences and how inference performance can be improved.

CHAPTER III

SUMMARY AND GENERAL DISCUSSION

The experiments described in the preceding chapter involved presenting subjects with potential inference sentences similar to those employed by Bransford, Barclay, and Franks (1972). In Experiment 2 evidence was obtained with adult subjects that imposing a delay between the potential inference sentence and the question about it resulted in the formation of a construct such that both the inference and direct answers were equally available to the subjects. This finding supports Bransford et al.'s constructive theory of sentence memory. Experiments 3 and 4 showed that in spite of the fact that the ten-year-old subjects were more proficient at drawing inferences than the six-year-olds were, the ten-year-olds did not draw the inferences spontaneously during the interval provided by the interpolated material. These results indicate that where children are concerned, there is a developmental lag between the age at which a child is capable of drawing an inference and the age at which he does so without prompting.

The results of the experiments discussed in the preceding chapter may be considered in terms of Piaget's theory of cognitive development and Rohwer's elaboration hypothesis. Piaget's theory will be discussed first, with reference to preoperational thought, concrete operations, and formal operations.

According to Piaget, preoperational thought (from two to seven years of age) is characterized by concreteness, egocentrism, irreversibility, and transductive reasoning. Preoperational thought is concrete in that it consists of a series of mentally pictured actions, especially manual operations. The concrete nature of preoperational thought is exemplified by the fact that when children younger than seven or eight years of age are asked to give definitions, they define things in terms of their uses (Piaget, 1964b, chap. 4).

"What is a fork?" "It is to eat with."

"What is a mother?" "For cooking dinner."

"What is rain?" "It's for watering."

Since preoperational thought consists of representations of actions, it is not surprising that the six-year-old children in Paris and Lindauer's (1976) study were capable of choosing the appropriate instrument when they were presented with sentences which described commonplace actions.

Since the mentally pictured actions (or "mental experiments" as Piaget calls them) mirror irreversible events in reality, preoperational thought is irreversible. Thus, when the preoperational child has, for example, observed a series of transformations in a display, he cannot imagine the sequence of transformations in reverse and arrive at the original state of the display. Similarly, if he has pursued a series of reasonings he cannot reverse the direction of his thinking to arrive back at the premise from which he started.

Preoperational thought is egocentric; that is, it is thought which is not conscious of its own processes and hence takes its own

point of view as absolute. For example, the preoperational child may assert that he has a brother, while denying that his brother has a brother. Similarly, the preoperational child imagines that the left-to-right order of a set of objects would be the same if the objects were viewed from the side of the table opposite to where he is standing (Piaget, 1964b, chap. 3). This habit of viewing relationships as absolute rather than relative, coupled with the irreversible nature of preoperational thought prevents the child from solving problems which require judgments about relationships. In transitivity problems, for example, the middle member of a 3-term series must be considered as being greater than the member of the series which precedes it and less than the member which follows it. Since the preoperational child deals in terms of absolute rather than relative relationships, he cannot use the middle term to arrive at a correct ordering of the three objects (Piaget, 1965, chap. 6). It is possible that the preoperational child has a similar difficulty with spatial inference problems. For example, consider the potential inference sentence:

> Two frogs were sitting on a log and the fish swam around the log.

Perhaps the preoperational child cannot simultaneously consider "the log" as being both "the thing that the frogs were sitting on" and "the thing that the fish swam around" in order to arrive at the conclusion that "the fish swam around the frogs". In other words, given the relationship between the actor and the direct noun and the relationship between the direct noun and the inference noun, the child cannot infer the relationship between the actor and the inference noun.

Piaget (1964b, chap. 6) has called reasoning during the pre-operational period intuitive or transductive. Transductive reasoning moves from the particular to the particular instead of proceeding from the particular to the general (induction), or from the general to the particular (deduction). Transductive judgments do not imply each other, but simply follow one another, after the manner of successive actions or perceptions, without any logical necessity. Transductive reasoning often leads the child to incorrect conclusions. Piaget cites the example of a child who observed that when a pebble was dropped into a glass of water, the water level rose. The child said that the water level rose because the pebble was heavy. Here the child juxtaposed two successive perceptions, namely, the weight of the pebble and the rise in the water level. On the other hand, transductive reasoning can sometimes lead to a correct conclusion, as, for example, when Piaget's daughter Jacqueline, on seeing her father getting hot water, said, "Daddy's getting some hot water, so he's going to shave" (Piaget, 1951; cited in Phillips, 1975).

This concept of transductive reasoning may be related to one of the findings of Experiment 3; namely, that the six-year-old children gave significantly more correct answers to inference questions when material had been interpolated between the potential inference sentence and the question than when there was no interpolated material. It was suggested that with interpolated material, the six-year-olds were forgetting at least some of the sentence content and answering the inference questions without reference to the potential inference sentence; that is, they were giving what they considered to be plausible answers.

In Piagetian terms, the giving of plausible answers may involve transduction. A plausible relationship is one that has been observed in the past, one that the child "knows" to be true, even though there is no logical necessity for the relationship to be true. The potential inference sentences described everyday activities (such as a mother carrying plates). The preoperational child knows that a mother does carry plates into the dining room, that a mother does give a boy clothes, and so on. Transduction came into play when the child forgot the potential inference sentence and answered the question on the basis of what he "knew".

During the concrete operational period (seven to eleven years of age) egocentrism declines, thought becomes reversible, and deductive and inductive reasoning emerge. Piaget views all these developments not as a spontaneous development in the life of the individual, but at least in part as a product of social intercourse. In the first place, social life makes the child aware of other people's viewpoints and he begins to realize that relationships are relative rather than absolute. Furthermore, as a result of interacting with others, the concrete operational child becomes aware of the need for logical justification of his judgments. In order to convince others of the correctness of his judgments, the child must first reflect upon his own thought and trace his thinking backwards from the conclusion to the original premise. In other words, the mental experiments of the concrete operational period tend to become reversible. In addition, the child is no longer content to explain a phenomenon simply in terms of any perceptually compelling event which preceded it. Rather, the child

wants to connect cause and effect by a logically necessary relation. Thus, transductive reasoning is replaced by induction and deduction. The ability of the concrete operational child to view relationships as relative rather than absolute and the reversible nature of concrete operational thought now make it possible for the child to solve problems involving relationships such as transitivity problems and spatial inference problems.

However, concrete operational thought does have its limitations. Concrete operational thought tends to concern itself with present reality and not with possibilities. Piaget and his associates (1958, chap. 16) demonstrated this aspect of concrete operational thought in a number of studies in which children and adolescents attempted to solve problems which appeared to be purely concrete but which actually required propositional logic for their solution. (For example, the subjects were required to discover the law of floating bodies, the equality of the angles of incidence and reflection, and the period of a pendulum.) Piaget's observations indicate that the concrete operational child does not solve a problem by formulating hypotheses about the relationship between the independent variables and the dependent variable and then systematically exploring these relationships. Instead, he begins by acting upon the experimental materials at hand and then trying to co-ordinate the results he has obtained into a coherent explanation. Since the child has not delineated all the possibilities at the outset, he can easily overlook a relevant variable.

This tendency for concrete operational thought to be concerned with organizing the real as opposed to exploring the potential may be

relevant when considering the performance of the ten-year-old children in Experiment 3. The ten-year-olds did not spontaneously draw the inference from the potential inference sentence during the interval provided by the interpolated material. Perhaps, in Piagetian terms one could say that the ten-year-olds were more concerned with remembering the information as given than with working out its implications and therefore they did not derive the inference until they were specifically required to do so.

The completion of reflective intelligence occurs during the period of formal operations which begins around 11 to 12 years of age. Once again, Piaget views social factors as playing an important role (1964b, chap 2). At 11 to 12 years of age, children form groups and devise rules for group play. The formation of rules and the application of these rules leads to discussion (or arguments) between the members of the group. This type of discussion requires that the child abandon his own point of view and adopt the attitude of others to the extent of following a line of argument that is based on premises that the child doesn't necessarily believe. ("If what you say is true, then such and such follows.") This ability to derive an implication from a premise without believing that premise to be true distinguishes formal operational thought from concrete operational thought. The concrete operational child cannot reason from a premise which runs counter to his own beliefs.

The hypothetico-deductive ability of the adolescent has its origins in social intercourse, but it extends to other situations, so that the adolescent when confronted with a problem (such as discovering

the law of floating bodies) can begin by formulating hypotheses about relationships while reserving judgment about which hypothesized relationship is correct until the physical experiment has been carried out. This is in contrast to the performance of the concrete operational child who first experiments with physical objects and then attempts to co-ordinate his observations. Formal operational thought is concerned with exploring possibilities and discovering implications, not just with organizing reality.

In Experiment 2, it was seen that adult subjects tended to derive the implication from the potential inference sentence spontaneously when material was interpolated between the potential inference sentence and the question about it. From a Piagetian point of view, this result is to be expected, since it is characteristic of formal operational thought to move from an assumption to its implications. This represents a change from the concrete operational thinking of the ten-year-olds, who derived the inference only when the task explicitly demanded it.

In addition to considering the results of the experiments described in Chapter II from a Piagetian point of view, one can also relate these results to Rohwer's work on elaboration. Although Rohwer believes that the concept of elaboration is applicable across a variety of verbal learning tasks (including the recall of connected discourse) the research which he reports (Rohwer, 1973) was concerned primarily with paired-associate learning of unrelated nouns and objects. Rohwer defines elaboration in a paired-associate learning task as a process which generates a common referent for the two items of the pair.

When the paired-associates are unrelated nouns, the common referent is an episode or a relation which involves both nouns either explicitly or implicitly. The developmental hypothesis which Rohwer formulated was that the older the learner the less explicit the prompt necessary to activate elaboration. This hypothesis was confirmed by a series of studies of paired-associate learning in which successful elaboration was operationally defined in terms of the number of correct recall or recognition responses.

Before an account of Rohwer's results can be given, the various types of prompts used must be described. Prompt types can be ordered in terms of the extent to which the prompt explicitly directs the subject to an event that can be used as a common referent for the item pairs. Antagonistic prompts create a situation which is the least conducive to elaboration by directing the subject to engage in an activity which prevents efforts to generate a common referent. For example, the subject may be instructed to repeat each pair of nouns as many times as possible during the interval between presentation of pairs. In the minimally explicit prompt condition, the subject is told merely to learn the noun pairs in order to be able to recall or recognize them later; thus, in the minimally explicit condition, the subject is free to choose his own learning strategy. Explicit prompts direct the subject to invent a referential event for the to-be-learned items. The subjects may be instructed, for example, to produce a sentence which contains the two nouns in the pair, or to produce an image in which the referents of the two nouns are interacting. In the augmented prompt condition the experimenter furnishes the subject with

a common referent for the two nouns, for example, by reading aloud a sentence which contains both nouns.

In discussing developmental changes in the effectiveness of various types of prompts, Rohwer considers two periods: childhood (four years to 11 or 12 years of age) and adolescence (11 or 12 years of age to adult). Each period is characterized by a shift in the effectiveness of one of the types of prompts. Through the childhood years, the explicit prompt becomes increasingly effective in activating elaboration. In the early years of childhood (prior to age eight), the augmented prompt is much more effective than the explicit prompt, while the explicit prompt does not differ from the minimally explicit prompt. In the later years of childhood, the explicit prompt increases in effectiveness and becomes as effective as the augmented prompt, while the minimally explicit prompt remains ineffective. These results confirm Rohwer's hypothesis that less explicit prompts are required to activate elaboration in older subjects. At the beginning of childhood, the subject requires an augmented prompt. At the end of childhood, an explicit prompt is sufficient.

The adolescent period is characterized by a dramatic shift in the relative effectiveness of the minimally explicit prompt. At 11 years of age, the augmented and explicit prompts are significantly superior to the minimally explicit prompt, while the minimally explicit prompt merely produces results equivalent to the antagonistic prompt. However, by age 16 the effectiveness of the minimally explicit prompt has increased to the point where the minimally explicit prompt is as effective as the explicit and augmented prompts. The minimally

explicit, explicit, and augmented prompts are all superior to the antagonistic prompt. The pattern of results during the adolescent period confirms the developmental hypothesis. At the beginning of adolescence, the minimally explicit prompt is ineffective in activating elaboration. At the end of adolescence, the minimally explicit prompt is as effective as the more explicit prompts and clearly superior to the antagonistic prompt.

Rohwer suggests that the shift in the effectiveness of the explicit prompt in the childhood years results from a growth in the child's ability to think of an appropriate event which will serve as a common referent for the two nouns. According to Rohwer, the problem that the child has in elaborating an appropriate mediator may be related to other characteristics of cognitive processes. For example, in Piagetian terms, prior to the shift in effectiveness of the explicit prompt, the child is at the preoperational level; the shift occurs when the child enters the period of concrete operations.

The shift in the effectiveness of the minimally explicit prompt during adolescence is attributed to a different type of change from that which occurs during childhood. Rohwer suggests that during adolescence there may be an increasing tendency to employ a "strategy-like orientation" when confronted with learning tasks. At the beginning of adolescence the subject is fully capable of elaborating when explicitly instructed to do so; by the end of adolescence the subject can "not only accomplish elaboration or cue but also uses it as a means for achieving other ends". Although Rohwer does not make the comparison, the change which he discovered in adolescence can also be

discussed in Piagetian terms. Piaget considers formal thought to be a second-order process in which thought reflects on, organizes, and utilizes the products of thought. This appears to be an appropriate description of how the subject at the end of adolescence responds in a paired-associate learning task with minimally explicit prompts.

The performance of children and adults in the experiments reported in the preceding chapter may be interpreted in terms of the elaboration hypothesis. The elaboration hypothesis asserts that "the psychological product of elaboration is an event that promotes semantic sharing among items that are initially disparate." In the case of the potential inference sentence, the "initially disparate" items may be the actor and the inference noun. The subject, in elaborating upon the information contained in the potential inference sentence discovers the relationship between the actor and the inference noun. The inference question acts as an explicit prompt to perform this elaboration. The poor performance of the six-year-old subjects on the inference questions indicates that they did not use the explicit prompt provided by the inference question to discover the relationship between the actor and the inference noun. Thus, the six-year-olds in the present study are similar to the younger children in Rohwer's paired-associate learning experiments.

The performance of the ten-year-olds on inference items was similar to that of the older children in the paired-associate learning studies. The ten-year-olds were capable of using the explicit prompt; that is, they answered the inference questions correctly. However, the latency data indicate that the ten-year-olds were not elaborating

spontaneously upon the information in the potential inference sentence during the interval provided by the interpolated material. In this respect, the ten-year-olds' performance was similar to that of the older children under the minimally explicit prompt condition in Rohwer's studies.

The adult subjects in the present study performed like the older adolescents and adults in Rohwer's studies. In the first place, the adults were able to make use of the explicit prompt provided by the inference question in order to arrive at the inference answer. In addition, the latency data show that during the delay interval the adults elaborated spontaneously upon the information contained in the potential inference sentence. Thus, the adult subjects in the present study (and in Bransford et al., 1972) performed like the older adolescents and adults in the minimally explicit prompt condition in Rohwer's experiments.

Rohwer's studies of paired-associate learning may furnish some relevant variables for research on the drawing of inferences and the formation of constructs. As the preceding discussion indicated, one factor is the explicitness of the prompt to elaborate (and the interaction between explicitness of prompt and the subject's age). In addition, in Chapter III it was pointed out that the nature of the relationship between the direct and inference objects may play a role in determining the ease with which inferences are drawn. The "easy" potential inference sentences were those in which the direct and inference objects were coupled by a dynamic relationship; in "hard" potential inference sentences the relationship was static. However,

the hypothesis that the nature of the relationship between the direct and inference objects determines the difficulty of the inference was arrived at after the fact. It is clear that in future studies both the relationship between the actor and the direct object and the relationship between the direct object and the inference object should be varied systematically. At the same time, the information conveyed by the sentence as a whole should be taken into consideration, for example, in terms of the change-no change dimension, or the concept of a journey.

In future studies it may prove fruitful to use a potential inference paragraph instead of a potential inference sentence. When a researcher creates a potential inference sentence he is restricted by the syntax of the sentence and this sometimes makes it difficult to vary the forms in which the information is presented. In the potential inference paragraph, the to-be-related information would be distributed over several sentences. This should make it possible to manipulate the interesting content variables: the relationship between the actor and the direct object, the relationship between the direct and inference objects, and the inference situation as a whole.

APPENDIX I

Potential Inference Stories Used in Experiment 1

(1)

1 A kind and gentle giant was walking through the woods.

2 The friendly giant danced and sang a happy song as he went along the path.

3 The birds were busy building their nests in the trees and bees were buzzing everywhere.

PI Potential Inference Sentence (PI). Two fairies were sitting on a daisy and the giant stepped over(them)(it).

Q1 The giant stepped over what?

Q2 Did the giant step over the (fairies) (daisy)?

(2)

1 One day a little fish was playing in a pond.

2 The fish wiggled his tail from side to side and made waves in the water.

3 It was almost supper-time and the young fish was beginning to feel very hungry.

PI Two frogs were sitting on a lily-pad and the fish swam around (them) (it).

Q1 The fish swam around what?

Q2 Did the fish swim around the (frogs) (lily-pad)?

(3)

1 Early one morning, a man was walking by the sea.

2 This man was a fisherman and he lived with his wife in a cottage nearby.

3 There wasn't anybody on the beach and no one saw what the man was doing.

PI The man put some pennies in a box and buried (them) (it) in the sand.

Q1 The man buried what?

Q2 Did the man bury the (pennies) (box)?

(4)

1 There was a quiet little town beside a large lake.

2 The lake was wide and deep and the water in the lake was very cold.

APPENDIX I (Cont'd)

3 In the middle of the lake there was a large island where wild birds lived.

PI Some hunters got into a boat and (they) (it) sailed across the lake.

Q1 What sailed across the lake?

Q2 Did the (hunters) (boat) sail across the lake?

(5)

1 One afternoon a girl was walking through her mother's garden.

2 The little girl went to each flower bed to see how the plants were growing.

3 The long grass was soft and it felt like a rug under the girl's feet.

PI Some caterpillars were hiding under a stone and the girl stepped over (them) (it).

Q1 The girl stepped over what?

Q2 Did the girl step over the (caterpillars) (stone)?

(6)

1 A six-year-old girl was having a birthday party.

2 The girl was wearing a pretty new dress and she had ribbons in her hair.

3 The other children gave the little girl some presents and the girl was very happy.

PI Her mother put some cookies on a plate and carried (them) (it) into the dining room.

Q1 Her mother carried what into the dining room?

Q2 Did the mother carry in the (cookies) (plate)?

(7)

1 A boy was flying his toy airplane in a field.

2 This little airplane had strong wings and a good motor and it could go fast.

3 The boy's father had given him the airplane and the boy was proud of it.

PI Some children were sitting in a tree and saw the toy airplane go past (them) (it).

Q1 The airplane went past what?

Q2 Did the airplane go past the (children) (tree)?

APPENDIX I (Cont'd)

(8)

1 A boy was walking through the woods near his home.

2 This boy liked to pretend that he was an Indian who lived in the forest.

3 It was fall, and the boy saw the birds were flying south for the winter.

PI The boy filled his pail with nuts and took (it) (them) home.

Q1 The boy took home what?

Q2 Did the boy take home the (pail) (nuts)?

(9)

1 One day a little boy went into a pet shop.

2 The boy wanted to buy his sister a present and he was looking at everything.

3 The man who owned the store was very busy and he didn't see the boy.

PI Some puppies were sleeping in a cage and the boy walked around (them)(it).

Q1 The boy walked around what?

Q2 Did the boy walk around the (puppies) (cage)?

(10)

1 At Christmas Santa visited a house where good children lived.

2 The family used to leave some cookies and milk beside the Christmas tree for Santa.

3 Eight reindeer pulled Santa's sleigh and they stood on the roof and waited for Santa.

PI Santa put some toys in his bag and brought (them) (it) into the house.

Q1 Santa brought in what?

Q2 Did Santa bring in the (toys)(bag)?

(11)

1 A fire-truck was hurrying to a fire in the city.

2 The fire-truck carried two tall ladders and a long hose for putting out the fire.

3 The brave firemen who rode on the fire-truck were wearing coats, hats and rubber boots.

PI A woman in a car watched the fire-truck rush past (her)(it).

APPENDIX I (Cont'd)

Q1 The fire-truck rushed past what?

Q2 Did the fire-truck rush past the (woman) (car)?

(12)

1 One morning a big eagle was flying through the sky.

2 The eagle was going from the green woods to his home in the high mountains.

3 The yellow sun was shining brightly and the eagle was beginning to feel very warm.

PI Two robins were sitting on their nest and the eagle flew over (them)(it).

Q1 The eagle flew over what?

Q2 Did the eagle fly over the (robins) (nest)?

(13)

1 One day in June a teacher was tidying the classroom.

2 The teacher rubbed off the blackboards and then she took the pictures off the walls.

3 The summer holidays were starting and no one would be in school until September.

PI The teacher put three snails in a jar and gave (them)(it) to the boy.

Q1 The teacher gave what to the boy?

Q2 Did the teacher give the (jar) (snails) to the boy?

(14)

1 One afternoon a mother was cleaning up the living room.

2 The mother was busy sweeping the floor and dusting the furniture.

3 It was late in the afternoon and the mother was hurrying to finish her work.

PI A boy was sitting in front of the television and his mother walked in front of (him)(it).

Q1 The mother walked in front of what?

Q2 Did the mother walk in front of the (television) (boy)?

(15)

1 One night a prince was listening to some soldiers talking.

2 The prince liked to hear stories about far away countries that he had never seen.

APPENDIX I (Cont'd)

3 It was past the prince's bed-time and he began to get sleepier and sleepier.

PI The king was sitting on his chair and the prince stood beside (him)(it).

Q1 The prince stood beside what?

Q2 Did the prince stand beside the (chair) (king)?

(16)

1 It was raining when the bus drove along the street.

2 The heavy bus went quickly through the big puddles and the water splashed around it.

3 The bus driver was in a hurry and he was making the bus go fast.

PI Some people were sitting at the bus-stop when the bus passed by (them)(it).

Q1 The bus passed by what?

Q2 Did the bus pass by the (people) (bus-stop)?

APPENDIX II

Filler Stories Used in Experiment 1

(1)

1. One day someone brought a baby robin to kindergarten class.
2. A boy was watching television and the robin sat on it.
3. The little robin was looking for his nest and he flew all around the room.
4. The teacher got some bread crumbs and she gave them to the robin to eat.

Q1. The robin sat on what?

Q2. Did the robin sit on the boy?

(2)

1. One sunny day a butterfly was flying over a field.
2. A girl was standing beside a flower and the butterfly landed on her.
3. The butterfly had orange wings with black stripes on them and the butterfly looked pretty.
4. It was early in the spring and the butterfly was looking for a new home.

Q1. The butterfly landed on what?

Q2. Did the butterfly land on the flower?

(3)

1. One day in the winter a boy was playing outside.
2. The boy jumped on his sleigh and he rode to the bottom of a hill.
3. It was getting very cold and the boy started to walk back to his home.
4. Some girls were building a snow man and the boy threw a snowball at them.

Q1. The boy threw a snowball at what?

Q2. Did the boy throw a snowball at the snow man?

(4)

1. One day a little fairy was walking along a road.
2. The fairy had bright yellow wings and she wore a gold crown on her head.
3. People said that the fairy brought good luck and they were happy to see her.

APPENDIX II (Cont'd)

4. Some horses were pulling a wagon and the fairy touched it with her wand.

Q1. The fairy touched what with her wand?

Q2. Did the fairy touch the horses?

(5)

1. Once long ago a sheriff saw a stage coach being robbed.
2. The bad man threw a rock at the sheriff and the sheriff caught him.
3. Then the sheriff called for help and all his friends came running to help him.
4. The people who lived in the town knew that the sheriff was very brave.

Q1. The sheriff caught what?

Q2. Did the sheriff catch the rock?

(6)

1. A lion was sitting in a tree looking for food.
2. The lion hadn't eaten anything for a whole week and he had become very hungry.
3. A little mouse saw the lion and the mouse ran under a bush to hide.
4. Two hunters came by, dragging a dead deer, and the lion jumped on them.

Q1. The lion jumped on what?

Q2. Did the lion jump on the deer?

(7)

1. A boy got sick and he went to the hospital.
2. The nurses gave the boy a teddy bear and the boy kissed it.
3. The little boy wanted to see his father and mother and he started to cry.
4. A doctor came to visit the boy and soon the boy began to feel better.

Q1. The boy kissed what?

Q2. Did the boy kiss the nurses?

APPENDIX II (Cont'd)

(8)

1. A circus clown went for a walk in a park.
2. The clown jumped into the air and landed upside down in a big sand box.
3. All the people were laughing at the clown's funny tricks and the clown was happy.
4. Two boys were flying a kite and the clown squirted water on it.

Q1. The clown squirted water on what?

Q2. Did the clown squirt water on the boys?

(9)

1. A boy was riding his bicycle for the first time.
2. The boy was learning to drive straight down the street and he kept on trying.
3. The little boy's brother and sister were watching him and they wanted to help him.
4. The mailman was walking past a tree and the boy crashed into him.

Q1. The boy crashed into what?

Q2. Did the boy crash into the tree?

(10)

1. One day a little puppy was looking for some fun.
2. The puppy ran along the street and barked at the cars that drove past him.
3. An oak tree was growing on the lawn and the puppy scratched some bark off.
4. Some boys were playing with a ball and the puppy chased it.

Q1. The puppy chased what?

Q2. Did the puppy chase the boys?

(11)

1. A young boy was busy in class painting a picture.
2. Two teachers were looking at the chalk board and the boy splashed paint on it.
3. It would soon be time to go home and the boy wanted to get finished.
4. All the children were drawing horses and the boy thought his horse was the best.

APPENDIX II (Cont'd)

Q1. The boy splashed paint on what?

Q2. Did the boy splash paint on the teachers?

(12)

1. One dark night a robber walked quietly into a home.
2. The robber wore a mask on his face and carried a flashlight in his hand.
3. The people who lived in the house were asleep and they didn't hear the robber.
4. Three kittens were sleeping beside a radio and the robber took it.

Q1. The robber took what?

Q2. Did the robber take the kittens?

(13)

1. A deer was running along a path through the woods.
2. The deer came to a river and he swam across it to the other side.
3. Some hungry wolves were chasing the deer and he wanted to get away from them.
4. A woman was walking toward her tent and the deer jumped over it.

Q1. The deer jumped over what?

Q2. Did the deer jump over the woman?

(14)

1. One day a little monkey went walking through a zoo.
2. A boy was holding a balloon and the monkey pinched him.
3. The monkey crawled into the lion's cage and then the monkey ticked the lion's nose.
4. A man was selling bags of popcorn and the monkey stole some popcorn from him.

Q1. The monkey pinched what?

Q2. Did the monkey pinch the balloon?

(15)

1. One summer afternoon a farmer was working in his field.
2. Some children brought the farmer a puppy and the farmer gave it some milk.

APPENDIX II (Cont'd)

3. The farmer had some cows and pigs and he was building a barn for them.
4. The people who lived in the country liked the farmer and they often visited him.

Q1. The farmer gave some milk to what?

Q2. Did the farmer give some milk to the children?

(16)

1. One day a baby girl was playing on a beach.
2. Some boy scouts were sleeping near their camp fire and the baby threw sand on them.
3. The baby took off her shoes and socks and she dropped them in the lake.
4. The baby's mother and father were looking everywhere for her and they couldn't find her.

Q1. The baby threw sand on what?

Q2. Did the baby throw sand on the camp fire?

APPENDIX III

Potential Inference Stories Used in Experiments 2, 3, and 4

(1)

1 A boy was going to visit his grandparents' farm.

2 The boy's father told him to be a good boy and gave him some money.

PI Potential Inference Sentence (PI). His mother packed some clothes in a box and gave the (clothes) (box) to the boy.

Q1 Did the mother give the boy the (clothes) (box)?

Q2 Was the boy going away to visit the zoo?

(2)

1 A kind and gentle giant was walking through the woods.

2 The friendly giant danced and sang a happy song while he went along the path.

PI Two elves were sitting on a daisy and the giant stepped over the (elves) (daisy).

Q1 Did the giant step over the (elves) (daisy)?

Q2 Was the gentle giant walking along a city street?

(3)

1 One day a little fish was playing in a pond.

2 It was almost suppertime and the little fish was beginning to feel hungry.

PI Two frogs were sitting on a log and the fish swam around the (frogs) (log).

Q1 Did the fish swim around the (frogs) (log)?

Q2 Was the young fish swimming around in the ocean?

(4)

1 Early one morning a man was walking by the sea.

2 Two children were playing on the beach and they saw what the man was doing.

PI The man put some pennies in a box and buried the (pennies) (box) in the sand.

Q1 Did the man bury the (pennies) (box)?

Q2 Was the man riding the bicycle along the beach?

APPENDIX III (Cont'd)

(5)

1 There was a quiet little town beside a large lake.

2 A big green monster lived in the water and it came out only at night.

PI Some men got into a boat and the (men) (boat) sailed across the lake.

Q1 Did the (men) (boat) sail across the lake?

Q2 Did the green monster come out in the daytime?

(6)

1 One afternoon a girl was looking at her mother's garden.

2 The long grass was soft and it felt like a rug under the girl's feet.

PI Some caterpillars were hiding under a stone and the girl stepped over the (caterpillars) (stone).

Q1 Did the girl step over the (caterpillars) (stone)?

Q2 Was a young boy walking through the lady's garden?

(7)

1 A six-year-old girl was having a birthday party.

2 The other children gave the little girl some presents and the girl was very happy.

PI Her mother put some cookies on a plate and carried the (cookies) (plate) into the dining room.

Q1 Did the mother carry in the (cookies) (plate)?

Q2 Was there a birthday party for a little boy?

(8)

1 A boy was flying his toy airplane in a field.

2 The boy's father had given him the airplane and the boy was proud of it.

PI Some children were sitting in a tree and the toy airplane went past the (children) (tree).

Q1 Did the airplane go past the (children) (tree)?

Q2 Was the little boy playing with a toy sailboat?

APPENDIX III (Cont'd)

(9)

1 A boy was walking through the woods near his house.

2 This boy liked to pretend that he was an Indian who lived in the forest.

PI The boy filled his pail with nuts and took the (pail) (nuts) home.

Q1 Did the boy take home the (pail) (nuts)?

Q2 Did the boy pretend that he was a bear?

(10)

1 One day a little boy went into a pet shop.

2 The boy wanted to buy his sister a present and he was looking at everything.

PI Some puppies were sleeping in a cage and the boy walked around the (puppies) (cage).

Q1 Did the boy walk around the (puppies) (cage)?

Q2 Did the little boy go into a grocery store?

(11)

1 One day some people met a bear in the forest.

2 The father was a very brave and strong man and he wasn't frightened at all.

PI The mother was carrying a basket of eggs and she dropped the (basket) (eggs).

Q1 Did the mother drop the (basket) (eggs)?

Q2 Did the people meet a man in the forest?

(12)

1 One night an old owl was hunting for some mice.

2 The dark forest was quiet and most of the animals who lived there were asleep.

PI Two racoons were sitting on a rock and the owl flew over the (racoons) (rock).

Q1 Did the owl fly over the (racoons) (rock)?

Q2 Was the old owl hunting for some little birds?

APPENDIX III (Cont'd)

(13)

1 At Christmas Santa visited a house where good children lived.

2 Eight reindeer pulled Santa's sleigh and they stood on the roof and waited for Santa.

PI Santa put some toys in his bag and brought the (toys) (bag) into the house.

Q1 Did Santa bring in the (toys) (bag)?

Q2 Did Santa have some horses to pull his sleigh?

(14)

1 A fire-truck was hurrying to a fire in the city.

2 The fire-truck carried two tall ladders and a long hose for putting out the fire.

PI A woman was sitting in a car and the fire-truck rushed past the (woman) (car).

Q1 Did the fire-truck rush past the (woman) (car)?

Q2 Was the fire-truck driving slowly along the city street?

(15)

1 One morning a big eagle was flying through the sky.

2 The yellow sun was shining brightly and the eagle was beginning to feel very warm.

PI Two robins were sitting on their nest and the eagle flew over the (robins) (nest).

Q1 Did the eagle fly over the (robins) (nest)?

Q2 Was the old eagle starting to feel very cold?

(16)

1 One day a teacher was getting ready for summer vacation.

2 The teacher rubbed off the chalk-board and then she took the pictures off the walls.

PI The teacher put three snails in a bottle and gave the (snails) (bottle) to a boy.

Q1 Did the teacher give the boy the (snails) (bottle)?

Q2 Was the teacher getting ready for the Christmas vacation?

APPENDIX IV

Filler Stories Used in Experiment 2

(1)

1. A horse and dog were arguing about who could run faster.
2. Then a parrot suggested that the two animals have a race.
3. The horse was winning, but the dog took a short cut and finished first.
4. The horse ran faster, but the dog was smarter.

Q1. Did the dog run faster than the horse?

Q2. Did the horse finish first?

(2)

1. A deer was running along a path through the woods.
2. The deer came to a river and he swam across it to the other side.
3. A woman was walking toward her tent and she saw the deer jump over it.
4. The deer was being chased by some hungry wolves and he was trying to get away from them.

Q1. Was the deer chasing some wolves?

Q2. Did the deer cross a river?

(3)

1. The young teacher was standing at the door of the old red school house, ringing the school bell.
2. It was the day of the big spelling bee.
3. Most of the children were on time that morning, but Tom was late.

Q1. Was the teacher old?

Q2. Was Tom early?

(4)

1. Once there was a wicked old dragon.
2. St. George fought with the dragon and St. George killed it.

Q1. Was St. George killed by the dragon?

Q2. Was the dragon wicked?

APPENDIX IV (Cont'd)

(5)

1. Once, long ago, a sheriff saw a stage coach being robbed.
2. The sheriff told the robber to drop his guns and the sheriff picked them up.
3. The sheriff tied up the robber and then he took the robber to jail.

Q1. Did the robber shoot the sheriff?

Q2. Did the robber get away?

(6)

1. A girl was buying her mother a present.
2. First, the girl looked at a small bottle of perfume.
3. Then she saw a pretty scarf, which was cheaper than the perfume.
4. The girl decided to buy the scarf.

Q1. Was the scarf more expensive than the perfume?

Q2. Did the girl buy the perfume?

(7)

1. One day a monkey got out of his cage and went running through the zoo.
2. A boy was holding a balloon and the monkey tried to take it.
3. A man was selling bags of popcorn and the monkey stole some when the man wasn't looking.

Q1. Did a big ape go running through the zoo?

Q2. Did the man give the monkey some popcorn?

(8)

1. A fisherman and a tailor lived in the same village.
2. The fisherman was taller than the tailor.

Q1. Was the tailor taller than the fisherman?

Q2. Was the fisherman taller than the tailor?

(9)

1. Once there was an old sailor who had a son and a daughter.
2. The son was rich, but the daughter was poor.

Q1. Was the son richer than the daughter?

Q2. Did the sailor have two children?

APPENDIX IV (Cont'd)

(10)

1. The big grey elephant was frightened by the tiny brown mouse.
2. The elephant raised his trunk in the air and trumpeted loudly.

Q1. Did the mouse frighten the elephant?

Q2. Was the mouse grey?

(11)

1. One day someone brought a robin to kindergarten class.
2. The little bird had a broken wing and it could not fly.
3. A boy was playing on the floor and the robin sat beside him.

Q1. Did the bird fly around the room?

Q2. Did the bird sit on the boy?

(12)

1. A boy was riding his bicycle for the first time.
2. The boy was small and his bicycle was too big for him.
3. The mailman was walking by and he saw the boy crash into a tree.
4. The boy stood up and got back on his bicycle.

Q1. Was the bicycle too small for the boy?

Q2. Did the boy fall off his bicycle?

(13)

1. One day a young man set out to find his fortune.
2. On the road he met an old woman who was too weak to carry her suitcase.
3. The man picked up the suitcase and carried it for the woman.
4. Later on, he was rewarded for his good deed.

Q1. Was the man old?

Q2. Was the woman stronger than the man?

(14)

1. One dark night a robber crept into a home.
2. The robber wore a mask on his face and carried a flashlight in his hand.
3. There was a wallet lying beside some books and the robber took it.

APPENDIX IV (Cont'd)

4. The people in the house didn't hear the robber.

Q1. Did the robber make a lot of noise?

Q2. Did the robber take the books?

(15)

1. When Jane got the good news, she sent her parents a telegram, and then she wrote them a letter.
2. The telegram was short, but the letter was long.

Q1. Was the news good?

Q2. Was the telegram long?

(16)

1. One summer afternoon, a farmer was working in his field.
2. The farmer had some cows and pigs and he was building a barn for them.
3. Some children brought the farmer a kitten, and the farmer fed it some milk.

Q1. Did the farmer give the children some milk?

Q2. Did the farmer own some animals?

(17)

1. A circus clown went for a walk in a park.
2. Two boys were flying a kite and the clown squirted water on the boys.
3. The clown was pleased with himself because everyone was laughing at his tricks.

Q1. Did the boys get wet?

Q2. Was the clown feeling sad?

(18)

1. Once upon a time, a farmer wanted to take his vegetables to market.
2. The farmer's horse was lazy and it wouldn't pull the wagon.
3. The farmer got a small donkey to help him.
4. The donkey pulled the wagon and the farmer gave the donkey some carrots.

Q1. Was the farmer going to market?

Q2. Was the horse lazier than the donkey?

APPENDIX IV (Cont'd)

(19)

1. One winter day a boy and his younger sister were playing in the snow.
2. The girl was building a snow man while the boy pulled his sleigh up the hill.

Q1. Was the boy older than his sister?

Q2. Was the sleigh pulled by the boy?

(20)

1. The king was sitting on his throne and the prince was sitting beside him.
2. They were listening to soldiers who were telling stories about far-away countries.
3. Although the prince was only a young boy he was already taller than the king.
4. It was past the prince's bed-time and he began to get sleepier and sleepier.

Q1. Was the king sitting beside the prince?

Q2. Was the king shorter than the prince?

(21)

1. A small grey cat and a brown dog were always fighting.
2. One day, when the dog was asleep, the cat crept up to him.
3. The dog opened his eyes and the cat scratched him on the nose.
4. Then the cat turned and ran away.

Q1. Was the cat small?

Q2. Did the cat scratch the dog?

(22)

1. A boy and his younger brother were fighting over a toy car.
2. The young boy hit his older brother and took the toy.

Q1. Were the two boys fighting?

Q2. Was the older boy hit by the younger boy?

APPENDIX IV (Cont'd)

(23)

1. A man was carrying a radio and a chair into his back yard.
2. He found that the chair was heavier than the radio.

Q1. Did the man carry the radio?

Q2. Was the radio lighter than the chair?

(24)

1. A lion was sitting beneath a tree looking for food.
2. The lion hadn't eaten anything for a week and he had become very hungry.
3. Two hunters came by, carrying a dead deer and the lion jumped on one of the hunters.
4. The two men fought with the lion, and the men got away.

Q1. Was the lion looking for something to eat?

Q2. Did the lion eat the hunter?

APPENDIX V

Filler Stories Used in Experiment 3

(1)

1. A circus clown went for a walk in a park.
2. Two boys were flying a kite and the clown squirted water on the boys.
3. Everyone was laughing at the clown's funny tricks and the clown was very happy.

Q1. Was the clown feeling happy?

Q2. Did the two boys get wet?

(2)

1. One day a boy was busy in class painting a picture.
2. It would soon be time to go home and the boy wanted to get finished.
3. All the children were drawing horses and the boy thought his horse was the best.

Q1. Was the boy busy playing the piano?

Q2. Did the boy think his picture was the worst?

(3)

1. An old farmer was getting ready to go to market.
2. The farmer wanted his big grey horse to pull the wagon, but the horse was too lazy to move.
3. The farmer pulled the wagon to market himself and the horse stayed on the farm.

Q1. Was the horse lazy?

Q2. Did the farmer pull the wagon?

(4)

1. One night a prince was listening to some soldiers talking.
2. The prince liked to hear stories about far-away countries that he had never seen.
3. One of the soldiers gave the prince a small sword.

Q1. Was the prince watching television?

Q2. Did the prince give the soldier a sword?

APPENDIX V (Cont'd)

(5)

1. One summer afternoon a farmer was working in his field.
2. The farmer had some cows and pigs and he was building a barn for them.
3. Some children brought the farmer a kitten and the farmer fed the kitten some milk.

Q1. Did the farmer give the kitten some milk?

Q2. Did the farmer have some animals?

(6)

1. One day a little girl went to visit her grandmother.
2. The girl's grandmother was sick and the girl gave her a bunch of flowers.
3. Grandmother gave the girl a doll and the girl took it home.

Q1. Did the girl give her grandmother a doll?

Q2. Did grandmother give the girl some flowers?

(7)

1. One day in the winter, a boy was playing outside.
2. Some girls were making a snow man and the boy threw a snow ball at the girls.
3. It was getting very cold and the boy started to talk back home.

Q1. Was the weather very warm?

Q2. Was the boy playing inside?

(8)

1. One sunny day a butterfly was flying over a field.
2. The butterfly had orange wings with black strips on them and the butterfly looked pretty.
3. A girl was standing beside a flower and the butterfly landed on the flower.

Q1. Did the butterfly land on the girl?

Q2. Did the butterfly have purple wings?

APPENDIX V (Cont'd)

(9)

1. A white rabbit found a package of carrot seeds.
2. The rabbit asked a little chicken to help plant the seeds, but the chicken said that she was too busy.
3. When the carrots were ready to eat, the rabbit would not give the chicken any.

Q1. Did the chicken find the seeds?

Q2. Did the chicken plant the seeds?

(10)

1. One dark night a robber walked quietly into a home.
2. The robber wore a mask on his face and carried a flashlight in his hand.
3. Three kittens were sleeping beside a radio and the robber took the radio.

Q1. Did the robber take the kittens?

Q2. Did the robber make a lot of noise?

(11)

1. One day a little monkey went walking through a zoo.
2. A boy was holding a baloon and the monkey pinched the boy.
3. A man was selling popcorn and the monkey stole some when the man wasn't looking.

Q1. Did the monkey take some popcorn?

Q2. Did the monkey pinch the boy?

(12)

1. One day someone brought a baby robin to kindergarten class.
2. The little robin had a broken wing and the robin could not fly.
3. A boy was sitting at his desk and the robin sat on the desk.

Q1. Did the robin fly around the room?

Q2. Did the bird sit on the boy?

APPENDIX V (Cont'd)

(13)

1. A rabbit was running along a path through the woods.
2. The rabbit came to a mud puddle and he jumped right over it.
3. A hungry fox was chasing the rabbit and the rabbit wanted to get away.

Q1. Was the rabbit being chased by a fox?

Q2. Did the rabbit jump over a puddle?

(14)

1. A boy got sick and he went to the hospital.
2. Some nurses gave the boy a teddy-bear and the boy said "thank you" to the nurses.
3. A doctor came to visit the boy and soon the little boy began to feel better.

Q1. Did the boy go to the hospital?

Q2. Did the nurses give the boy a teddy-bear?

(15)

1. A boy was riding his bicycle for the first time.
2. The boy was trying to go straight down the street.
3. The little boy's brother and sister were watching him and they tried to help him.

Q1. Was the boy learning to ride a bicycle?

Q2. Were the boy's brother and sister watching him?

(16)

1. One day a little girl was playing on a beach.
2. Some boy scouts were sleeping near their camp fire and the baby threw some sand at the boy scouts.
3. The baby's mother and father were looking everywhere for her and they could not find her.

Q1. Was the little girl playing on a beach?

Q2. Did the girl throw sand at the scouts?

APPENDIX VI

Filler Stories Used in Experiment 4

(1)

1. One day a brother and sister were playing in the snow.
2. The boy was making a snow man and the girl was pulling a sleigh.
3. The children heard their mother call them and they went home.

Q1. Was it winter-time?

Q2. What was the boy making?

Q3. What was the girl pulling?

Q4. Did the children go home?

(2)

1. One day a cowboy was working on his ranch.
2. The cowboy's brown horse was standing in the yard and there was a fence around the yard.
3. The horse jumped over the fence and the cowboy ran after the horse.

Q1. Was the cowboy working on his ranch?

Q2. What did the cowboy run after?

Q3. What did the horse jump over?

Q4. Did the horse jump over the cowboy?

(3)

1. A boy was riding his bicycle for the first time.
2. The little boy was trying to go straight down the street.
3. The mailman was walking by and he saw the boy crash into a tree.

Q1. Was the boy learning to ride a bicycle?

Q2. What did the boy crash into?

Q3. What was walking by?

Q4. Did the boy crash into the mailman?

(4)

1. One day a little monkey went walking through a zoo.
2. A boy was holding a balloon and the monkey pinched the boy.
3. A man was selling popcorn and the monkey stole some when the man wasn't looking.

APPENDIX VI (Cont'd)

Q1. What did the monkey pinch?

Q2. What was the boy carrying?

Q3. Did the monkey pinch the balloon?

Q4. Did the monkey take some popcorn?

(5)

1. One dark night a robber walked quietly into a home.
2. The robber wore a mask on his face and carried a flashlight in his hand.
3. Three kittens were sleeping beside a radio and the robber took the radio.

Q1. What did the robber take?

Q2. What was beside the radio?

Q3. Did the robber take the kittens?

Q4. Did the robber make a lot of noise?

(6)

1. One day in the winter a boy was playing outside.
2. A girl was making a snow man and the girl threw a snow ball at the boy.
3. It was getting very cold and the boy started to walk back home.

Q1. What did the girl throw at the boy?

Q2. What was the girl doing?

Q3. Did the girl throw a snow ball at the snow man?

Q4. Was the weather very warm?

(7)

1. One day in the summer a bee was flying around in a garden.
2. The bee went from flower to flower looking for a place to land.
3. A girl was playing with her puppy and the bee stung the girl.

Q1. What did the bee sting?

Q2. What was the girl playing with?

Q3. Did the bee sting the puppy?

Q4. Was it in the winter-time?

APPENDIX VI (Cont'd)

(8)

1. A boy got sick and he went to the hospital.
2. Some nurses gave the boy a teddy-bear and the boy kissed the teddy-bear.
3. A doctor came to visit the boy and soon the boy began to feel better.

Q1. Did the boy go to the hospital?

Q2. What did the boy kiss?

Q3. What gave the boy the teddy-bear?

Q4. Did the boy kiss the nurses?

(9)

1. A circus clown went for a walk in a park.
2. Two boys were flying a kite and the clown squirted water on the boys.
3. Everyone was laughing at the clown's funny tricks and the clown was very happy.

Q1. What did the clown squirt on the boys?

Q2. What were the boys playing with?

Q3. Did the clown squirt water on the kite?

Q4. Was the clown feeling happy?

(10)

1. One day a hungry lion was looking for some food.
2. A hunter came by, dragging a dead deer and the lion jumped on the hunter.
3. The hunter fought with the lion and the hunter got away.

Q1. Was the lion hungry?

Q2. What came walking by?

Q3. What was the hunter dragging?

Q4. Did the lion jump on the hunter?

(11)

1. One summer afternoon a farmer was working in his farm-yard.
2. The farmer has some cows and pigs and he was building a barn for them.

APPENDIX VI (Cont'd)

3. Some children gave the farmer a kitten and the farmer fed the kitten some milk.

Q1. What did the farmer feed to the kitten?

Q2. Who gave the kitten to the farmer?

Q3. Did the farmer feed the children some milk?

Q4. Did the farmer have some animals?

(12)

1. One day a little girl was playing on a beach.
2. Some boy-scouts were sitting near their camp-fire and the baby threw some sand on the boy-scouts.
3. The baby's mother and father were looking everywhere for her and they could not find her.

Q1. Was the little girl playing on a beach?

Q2. What did the girl throw on the boy-scouts?

Q3. What were the boy-scouts sitting beside?

Q4. Did the girl throw sand on the camp-fire?

(13)

1. A puppy ran away from home and went into a park.
2. The puppy saw a children's swimming pool and he went swimming in it.
3. Two girls were sitting on a bench and the puppy barked at the girls.

Q1. What did the puppy bark at?

Q2. Where were the girls sitting?

Q3. Did the puppy bark at the bench?

Q4. Did the puppy go swimming?

(14)

1. One day a girl went to her grandmother's house.
2. The girl's grandmother was sick and the girl gave her grandmother some flowers.
3. Grandmother gave the girl a doll and the girl took it home.

Q1. Did the girl go to her grandmother's house?

Q2. What did the girl give her grandmother?

Q3. What did grandmother give the girl?

Q4. Was grandmother sick?

APPENDIX VI (Cont'd)

(15)

1. On Halloween night a family was having some fun.
2. The children dressed up in old sheets and they looked like ghosts.
3. The mother made candy and the father went to the store and bought a pumpkin.

Q1. Was it Halloween?

Q2. What did the mother make?

Q3. What did the father buy?

Q4. Did the children dress up in sheets?

(16)

1. One sunny day a butterfly was flying over a field.
2. The butterfly had orange wings with black stripes on them and the butterfly looked pretty.
3. A girl was standing beside a flower and the butterfly landed on the flower.

Q1. What did the butterfly land on?

Q2. What was beside the flower?

Q3. Did the butterfly land on the girl?

Q4. Did the butterfly have purple wings?

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